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LLNL-TR-404821

Documented Safety Analysis for the Waste Storage Facilities

D.T. Laycak

June 23, 2008

Disclaimer

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

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ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
ALARA	As-low-as-reasonably-achievable
ARF	Airborne Release Fraction
CCR	California Code of Regulations
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CM	Configuration Management
CSE	Criticality safety evaluation
D&D	Decontamination and Decommissioning
DBA	Design Basis Accident
DBE	Design Basis Earthquake
DBFl	Design Basis Flood
DBW	Design Basis Wind
DOE	Department of Energy
DOT	Department of Transportation
DR	Damage Ratio
DSA	Documented Safety Analysis
DTSC	Department of Toxic Substances Control
DWTF	Decontamination and Waste Treatment Facility
EBA	Evaluation Basis Accident
EG	Evaluation Guideline
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ERO	Emergency Response Organization
ERPG	Emergency Response Planning Guideline
ES&H	Environment, Safety, and Health
ESH&Q	Environment, Safety, Health and Quality
EVA	Emergency Voice Alarm
FFA	Federal Facilities Agreement
FFCA	Federal Facilities Compliance Act
FGE	Fissile Gram Equivalent

FHA	Fire Hazard Analysis
FSAR	Final Safety Analysis Report
FSP	Facility Safety Plan
HC	Hazard Category
HDPE	High Density Polyethylene
HWCL	Hazardous Waste Control Law
IDLH	Immediately Dangerous to Life or Health
ISM	Integrated Safety Management
IWS	Integration Work Sheet
LCO	Limiting Condition for Operation
LLNL	Lawrence Livermore National Laboratory
LLNS	Lawrence Livermore National Security
LLW	Low-Level Waste
LPF	Leak Path Factor
LPG	Liquified propane gas
MAR	Material at Risk
MOI	Maximally-Exposed Offsite Individual
NDA	Nondestructive Assay
NFPA	National Fire Protection Association
NPH	Natural Phenomena Hazard
OEL	Occupational Exposure Limit
OS	Other Structure
OSHA	Occupational Safety and Health Administration
PC	Performance Category
PE-Ci	^{239}Pu-equivalent Curies
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
PrHA	Process Hazard Analysis
QA	Quality Assurance
QAMP	Quality Assurance Management Plan
QAP	Quality Assurance Plan
RCRA	Resource Conservation and Recovery Act
RF	Respirable Fraction
RHWM	Radioactive and Hazardous Waste Management
RQ	Reportable Quantity

RWQCB	Regional Waste Quality Control Board
RWSA	Radioactive Waste Storage Area
SC	Safety Class
SCIL	Single Container Inventory Limit
SIH	Standard Industrial Hazard
SMP	Safety Management Program
SP	Safety Plan
SS	Safety Significant
SSC	Structure, System, or Component
ST	Source Term
SWB	Standard Waste Box
SWPA	Solid Waste Processing Area
TEDE	Total Effective Dose Equivalent
TIM	Training Implementation Matrix
TLV	Threshold Limit Value
TQ	Threshold Quantity
TRU	Transuranic
TRUW	Transuranic Waste
TSCA	Toxic Substances Control Act
TSR	Technical Safety Requirement
UBC	Uniform Building Code
UC	University of California
USQ	Unreviewed Safety Question
WCI	Weapons and Complex Integration
WAC	Waste Acceptance Criteria
WDR	Waste Disposal Requisition
WIPP	Waste Isolation Pilot Plant

EXECUTIVE SUMMARY

E.1 Facility Background and Mission

This documented safety analysis (DSA) for the Waste Storage Facilities was developed in accordance with 10 CFR 830, Subpart B, “Safety Basis Requirements,” and utilizes the methodology outlined in DOE-STD-3009-94, Change Notice 3.

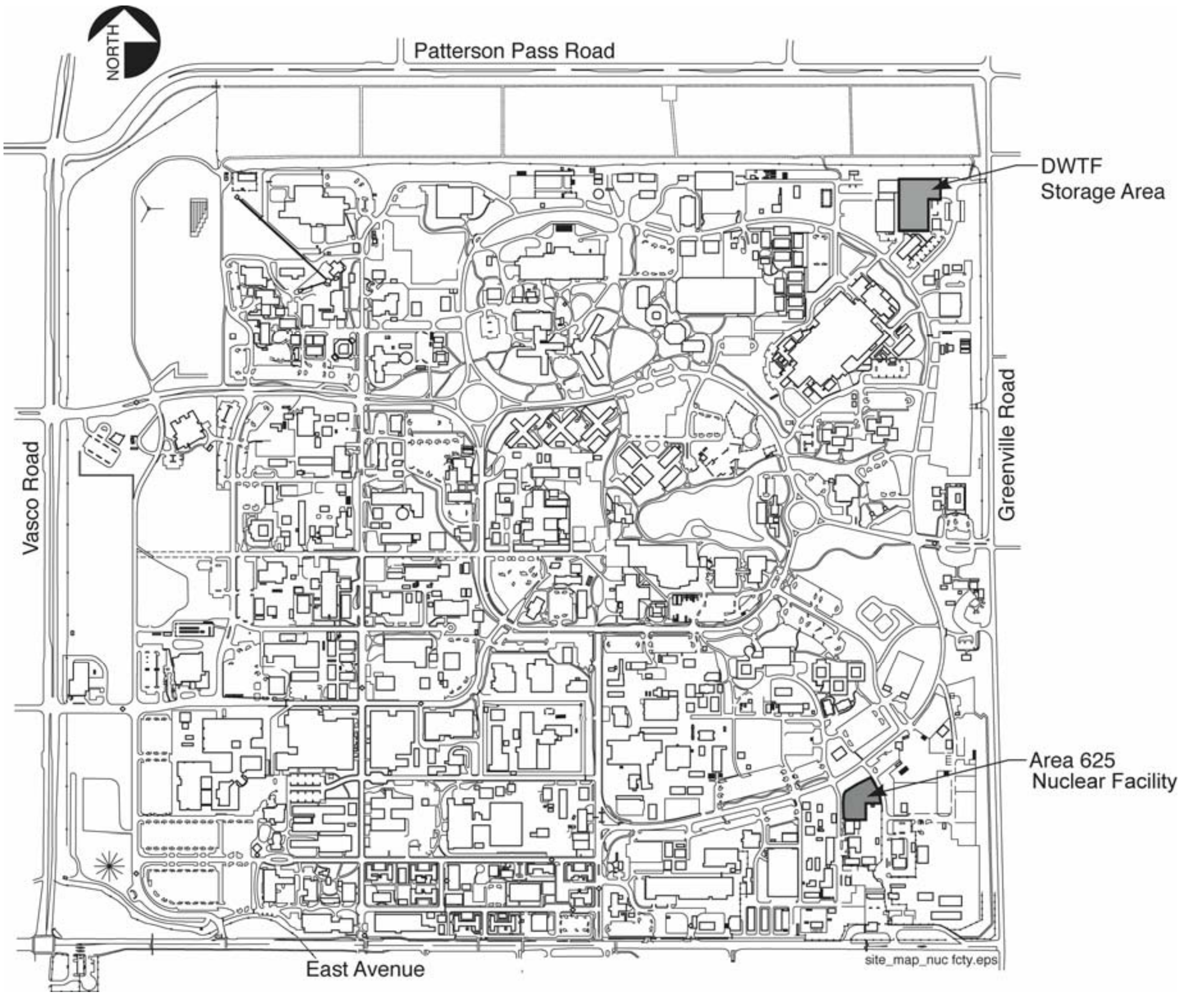
The Waste Storage Facilities consist of Area 625 (A625) and the Decontamination and Waste Treatment Facility (DWTF) Storage Area portion of the DWTF complex. These two areas are combined into a single DSA, as their functions as storage for radioactive and hazardous waste are essentially identical. The B695 Segment of DWTF is addressed under a separate DSA. This DSA provides a description of the Waste Storage Facilities and the operations conducted therein; identification of hazards; analyses of the hazards, including inventories, bounding releases, consequences, and conclusions; and programmatic elements that describe the current capacity for safe operations.

The mission of the Waste Storage Facilities is to safely handle, store, and treat hazardous waste, transuranic (TRU) waste, low-level waste (LLW), mixed waste, combined waste, nonhazardous industrial waste, and conditionally accepted waste generated at LLNL (as well as small amounts from other DOE facilities).

E.2 Facility Overview

The Waste Storage Facilities are located in two portions of the LLNL Main Site (Site 200), as shown in **Figure Ex-1**. A625 is located in the southeast quadrant of LLNL. The DWTF Storage Area, which includes Building 693 (B693), Building 696 Radioactive Waste Storage Area (B696R), and associated yard areas and storage areas within the yard, is located in the northeast quadrant of LLNL in the DWTF complex. A625 and the DWTF Storage Area are subdivided into various facilities and storage areas, consisting of buildings, tents, other structures, and open areas. Utilities are provided as part of the LLNL infrastructure. LLNL has an onsite Fire Department on site, as well as a Health Services Department for medical support.

Figure Ex-1. Waste Storage Facilities at LLNL



E.3 Facility Hazard Classification

The Waste Storage Facilities have been determined to be Hazard Category 2 nuclear facilities. This categorization was determined by comparing the facility inventory of radionuclides with threshold values for the various hazard-classification levels in accordance with Section 3 of DOE-STD-1027-92, Change Notice 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. The hazard classification defines the required level of safety documentation and the DOE orders governing the safety analysis.

The chemical hazard classification of low-hazard was determined by a comparison of chemical inventories with published threshold values.

E.4 Safety Analysis Overview

This section provides an overview of the Waste Storage Facilities operations and the results of the safety analysis.

- These facilities are primarily used for handling and storing containerized waste. The types of waste include hazardous waste, TRU waste, LLW, mixed waste, combined waste, nonhazardous industrial waste, and conditionally accepted waste. In addition, several minor treatments (e.g., size reduction and decontamination) are carried out in the Waste Storage Facilities. Operations and activities include (but are not limited to) moving containerized waste, maintaining integrity of waste containers, bulking, overpacking, surveying and assaying, lab packing, and sampling waste.
- The A625 and DWTF Storage Area facilities are consolidated into one DSA in order to standardize the safety provisions for all RHWM waste storage facilities and to reduce the administrative burden for document preparation and approval.
- The Hazard Analysis evaluated both radiological and chemical hazards, and concluded that the hazard of primary concern associated with the Waste Storage Facilities is TRU waste. A number of radiological release scenarios were, therefore, brought forward for Accident Analysis. The design basis accidents (DBAs) are:
  - Deflagration in a TRU waste drum.
  - A spill involving multiple TRU waste containers being staged outside of a building.
  - A fire involving multiple TRU waste containers stored inside a building.
  - A fire involving multiple LLW containers containing tritium stored inside a building.
  - A spill and fire involving multiple TRU waste containers being staged outside of a building.
  - An aircraft crash into a TRU waste storage building.
- It is concluded from the Hazard and Accident Analyses that no passive or active system, structure, or component (SSC) should be classified as *safety class*. The following passive SSCs have been identified as *safety significant*: TRU waste containers; the Performance Category 2 structure of Waste Storage Facilities buildings used to store TRU waste, including B625 and B696R; and the B696S/B696R partition. The Technical Safety Requirements for the Waste Storage Facilities will include: the safety significant SSCs as design features, a number of specific administrative controls relating to inventory limits and waste container handling and storage, and programmatic administrative controls.

E.5 Organizations

The Radioactive and Hazardous Waste Management (RHWM) Division of Weapons and Complex Integration (WCI) at LLNL is responsible for maintenance and operation of the Waste Storage Facilities. Facility safety is the joint responsibility of the Nuclear Operations Directorate, the RHWM Division, LLNL Hazard Control Department Environment, Safety, and Health Team 1, and the LLNL onsite Fire Department. This DSA was prepared by RHWM personnel with facility personnel information.

E.6 Safety Analysis Conclusions

Facility risk is a measure of the effectiveness of the design and administrative controls in reducing the probability of operational hazards impacting workers, the public, and the environment. In this report, it is concluded that for the accidents analyzed, the overall risk to workers, the public, and the environment during the operation of the Waste Storage Facilities is adequately analyzed and appropriate controls have been developed. The safety analysis shows that the mitigated risk to workers and the public for all facility operations is low or negligible.

E.7 DSA Organization

This DSA was developed in accordance with the 10 CFR 830 “Safe Harbor” methodology outlined in DOE-STD-3009-94, Change Notice 3.

CHAPTER 1
SITE CHARACTERISTICS

1.1 Introduction

This chapter provides an overview of the site characteristics of the LLNL Main Site (Site 200) and the Radioactive and Hazardous Waste Management (RHWM) Waste Storage Facilities, which includes Area 625 (A625) and the Decontamination and Waste Treatment Facility (DWTF) Storage Area, that are necessary for understanding these facilities and their operations. The remainder of the DWTF complex, consisting of the B695 Segment of DWTF, is addressed under a separate DSA. All references to the LLNL site in this document will be to the Main Site. The Site 300 waste storage facility is covered by a different authorization basis document.

The RHWM Waste Storage Facilities are low chemical-hazard facilities. Based on the inventory of transuranic (TRU) waste, these facilities are Hazard Category 2 nuclear facilities. The information presented herein provides support for the assumptions in the hazard and accident analyses used to identify and analyze potential external and natural phenomena accidents. Sections on site description (geography, demography), environmental description (meteorology, hydrology, geology), natural phenomena threats, external threats, nearby facilities, and validity of existing environmental analyses provide this support information. Complete discussions of the LLNL site geology, seismology, demography, local and regional meteorology, climatology, regional land and water use patterns, and hydrology are presented in the LLNL Environmental Impact Statement (EIS) (DOE 2005).

1.2 Requirements

Waste storage facilities are operated to conform to applicable laws and regulations, applicable DOE guidelines, NNSA/LLNS Contract (NNSA/LLNS 2007), and LLNL requirements. A list of key requirements is provided below.

U.S. Department of Energy

DOE O 420.1A, §4.4 Natural Phenomena Hazards Mitigation	Facility Safety (2002)
DOE-STD-1020-94, Change Notice 1	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities (1996)
DOE-STD-1020-2002	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities (2002)
DOE-STD-1021-93, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components (2002)
DOE-STD-1022-94, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Characterization Criteria (2002)
DOE-STD-1023-95, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Assessment Criteria (2002)
DOE-STD-3009-94, Change Notice 3	Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports (2006)

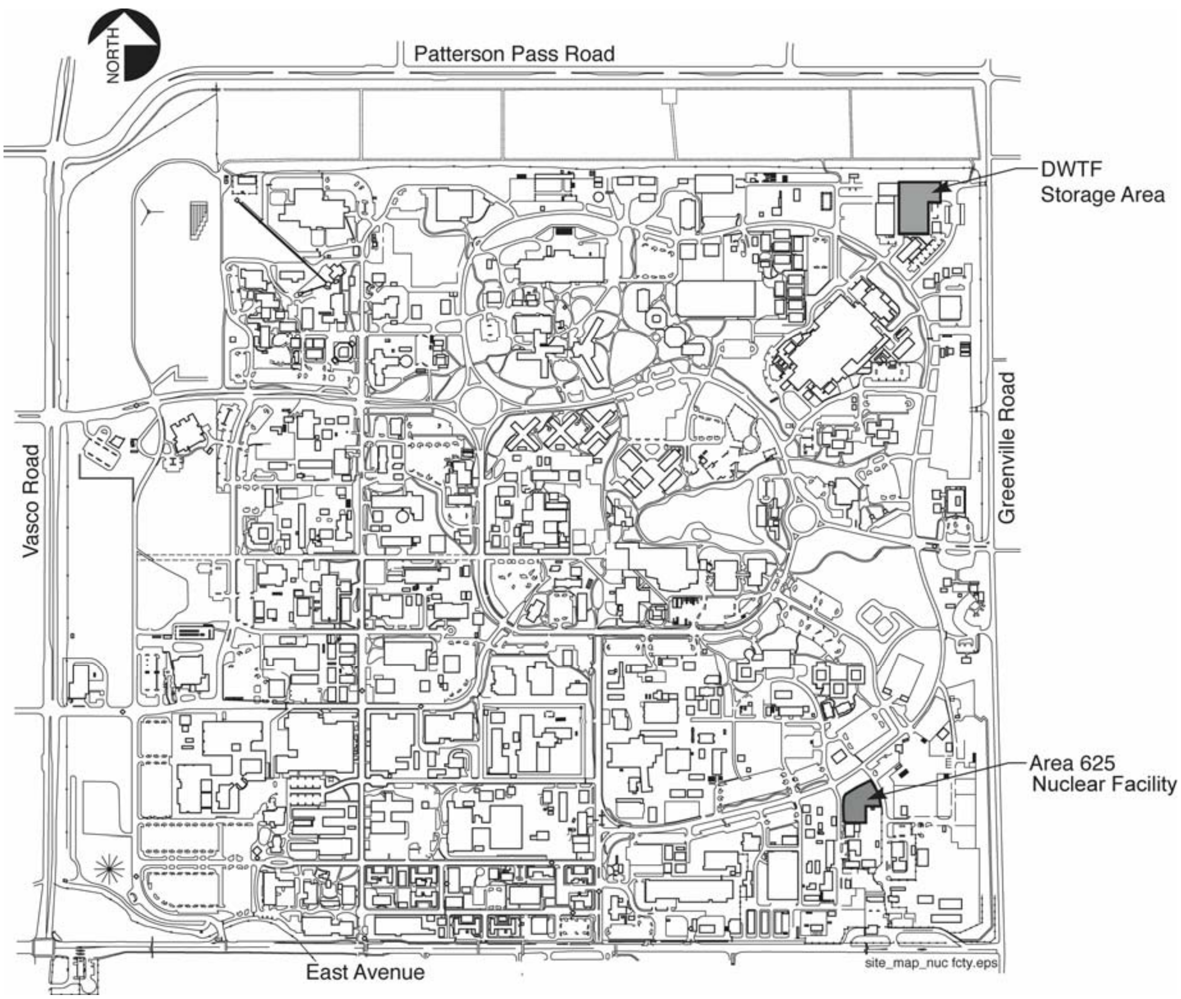
Code of Federal Regulations

10 CFR 830, Subpart B	Safety Basis Requirements

1.3 Site Description

The RHWM Waste Storage Facilities are located in two portions of LLNL, as shown in **Figure 1-1**. A625 is located in the southeast quadrant of LLNL. The A625 fenceline is approximately 225 m west of Greenville Road. The DWTF Storage Area, which includes Building 693 (B693), Building 696 Radioactive Waste Storage Area (B696R), and associated yard areas and storage areas within the yard, is located in the northeast quadrant of LLNL in the DWTF complex. The DWTF Storage Area fenceline is approximately 90 m west of Greenville Road. Chapter 2 describes the layout of the two areas.

Figure 1-1. Waste Storage Facilities at LLNL



1.3.1 Geography

LLNL occupies an area of approximately 1.3 square miles approximately 40-miles east of San Francisco at the southeast end of the Livermore Valley in Alameda County, California. The Livermore Valley is surrounded by hills that define the region and open space around the development on the valley floor. The terrain in the vicinity of the LLNL site ranges from relatively flat land to gently rolling hills. The hills east and south of LLNL gradually become steeper as they trend eastward to form the Altamont Hills of the Diablo Range.

The topographic surface at LLNL is of low relief and slopes gently to the northwest. Site elevation is 675-feet above sea level at the highest point in the southeast corner. Slopes or grades of the surrounding area range from 1% to 3.4%, except for the few stream banks or the sides of drainage ditches, where slopes or grades average 50%.

Significant man-made features include an earthfill embankment on the Arroyo del Valle forming the Del Valle Reservoir 7 miles southwest of the site. Livermore Municipal airport is located 6.5 miles west of the site.

1.3.2 Demography

The city of Livermore's central business district is located approximately 3-miles to the west of LLNL. The site is bordered on the east by Greenville Road, on the north by Patterson Pass Road, on the west by Vasco Road, and on the south by East Avenue. East Avenue is closed to through traffic between Vasco and Greenville Roads. Rural residences and grazing land are the primary land uses to the east of the site. Sandia National Laboratory is located to the south. The rural character continues to the southwest, where large vineyards are located. Residential areas of the city of Livermore extend to LLNL's site boundary on the west. The area extending north from LLNL to Interstate 580 is industrial and includes research, business, and industrial sites. Primary features in this area are one- and two-story industrial buildings, business parks, and a railroad line that traverses the area.

The population in Alameda County in the year 2000 was 1,443,741; of these, 73,345 lived within the City of Livermore (2000 Census).

1.4 Environmental Description

1.4.1 Meteorology

The mean annual temperature at LLNL for the 30-year period from 1951 through 1980 was 58°F.

The Livermore Valley has mild, rainy winters and warm, dry summers. Most rainfall occurs between October and April. The highest and lowest annual rainfalls on record were 30.6 inches (1982-83) and 6.1 inches (1975-76 and 1976-77), with a 25-year average of 13.3 inches (Thorpe 1990).

During the summer months, winds are predominantly from the south or southwest, as a result of sea breeze. During the winter months, winds are more evenly distributed because of the passage of winter storms and because of the smaller temperature differential between the land surface and ocean water. The wind speeds measured at the 10-m meteorological tower located at the LLNL site range from calm winds (0 to 1 m/sec) to more than 10.8 m/sec. The frequency of wind speed greater than 10.8 m/sec is 0.07% of the time. The frequency of wind speeds ranging from 0 to 1.3 m/sec is 39% of the time, due to the typically calm nights. **Table 1-1** (Gouveia 1989) shows atmospheric stability data.

Table 1-1. Meteorological Data for LLNL

Stability Class	A	B	C	D-Day	D-Night	E	F
Annual Frequency (%)	10.8	5.8	11.7	14.7	25.2	12.8	19.0
Z_m - (height of the inversion layer, m)	1200	1050	900	750	700	570	400

1.4.2 Hydrology

LLNL is located at the eastern end of the Livermore Valley groundwater basin. Recharge to the basin is largely from arroyos that originate in the foothills, including Arroyo Seco and Arroyo Las Positas, which cross the LLNL site. Waste storage areas are not located within the 100-year flood plain. To the north of the DWTF, a chain link fence crosses the Arroyo Las Positas with approximately 8-in clearance above the bottom of the channel. This fence has a locked flap gate used for security purposes. Water height is monitored constantly during storms. No springs are identified on the topographic map (USGS 1981) within 1 mile of LLNL. Components of the public water supply system within 1 mile of LLNL include the South Bay Aqueduct and the Patterson Pass Reservoir and Water Treatment Plant.

Within the Livermore Valley, uppermost-saturated sediments are commonly unconfined. Interbeds and interlenses of low-conductivity sediments within the saturated zone act as local aquitards, which tend to confine the deeper water-bearing zones (Thorpe 1990). The two most important formations that contain groundwater are Quaternary alluvial deposits and the Plio-Pleistocene Livermore Formation. The Livermore Formation is generally of lower permeability than the overlying deposits, but it commonly contains significant water-bearing zones. The LLNL area groundwater locally recharges by percolation through the valley alluvium and by infiltration via Arroyo Seco and Arroyo Las Positas as well as from unlined drainage ditches. A recharge basin (located south of LLNL) is a significant source of groundwater recharge. The basin receives treated groundwater from the southwest portion of LLNL. An artificially constructed drainage retention basin (located near the center of LLNL) has been lined to prevent the infiltration of storm water and treated groundwater discharge to the basin.

In general, groundwater flows toward the east-west longitudinal axis of the Livermore Valley and then in a westward direction to the gravel pit mines and the municipal water supply wells near Livermore and Pleasanton. Vertical movement of water between the lower member of the Livermore Formation and the overlying alluvial sediments is restricted by permeability differences and by internal stratification within these sedimentary units. At LLNL, the upper 15-feet to 60-feet of the lower member of the Livermore Formation is known to act as an aquitard (Thorpe 1990). Under LLNL, the contact between distinctively colored units in the lower member of the Livermore Formation generally dips to the west and is found between approximately 25-feet and 400-feet below the ground surface.

1.4.3 Geology

LLNL lies in the California Coastal Range province between the San Francisco Bay to the west and the northern San Joaquin Valley to the east. The Livermore Valley is generally of low relief, but contains scattered groups of hills that rise to 150-feet above the valley floor. The valley is surrounded by the Tassajara Hills and Mount Diablo to the north, the Altamont Hills to the east, the Diablo Range to the south, and the Hayward Hills to the west.

The Livermore Valley is an east–west-trending synclinal structure composed primarily of gently deformed alluvial deposits overlying complexly deformed Cenozoic and Mesozoic rocks. The California Coast Range in the Livermore region consists of north-to-northwest-trending mountain ranges and valleys bounded by faults. Most of the faults in the region are right-lateral strike-slip faults associated with the San Andreas Fault system. The Calaveras Fault to the west, and the Greenville Fault to the east border the Livermore Valley.

The oldest rock units exposed in the Livermore area consist of the highly deformed sedimentary, igneous, and metamorphic rocks of the Jurassic-Cretaceous Franciscan Assemblage. The Cretaceous Great Valley Sequence, consisting of alternating beds of sandstone, siltstone, and shale, structurally overlies these rocks. Both of these units are intricately folded and faulted in the mountains surrounding the Livermore Valley. More gently folded Tertiary sedimentary and igneous rocks overlie the Franciscan Assemblage and the Great Valley Sequence.

In the Livermore Valley, valley fill deposits are composed of as much as 4000-feet of Late Tertiary to Holocene fluvial and lacustrine sediments according to the California Department of Water Resources (CDWR 1974). The oldest Livermore Valley fill deposit is the Plio-Pleistocene Livermore Formation, which has been divided into two members based on lithology and depositional environment. The lower member of the Livermore Formation consists of a poorly cemented pebble conglomerate, sandstone, and greenish-gray claystone of late Pliocene age (Dibblee 1980). The upper member consists of light reddish-gray, cobble-pebble gravel with varying amounts of claystone of Pleistocene age (Dibblee 1980).

1.5 Natural Phenomena Threats

This section identifies specific natural phenomena events, such as design-basis earthquakes (DBEs) considered to be potential accident initiators. The natural phenomena threats used in the evaluation of the Waste Storage Facilities are supported by information contained in Chapter 3, "Hazard and Accident Analyses."

1.5.1 Earthquakes

The 2005 LLNL EIS (DOE 2005) provides details of the local and regional faults as well as historic earthquake data. The potential for seismic hazards at the Livermore Site are presented in the 2005 LLNL EIS and summarized below.

Strong earthquake ground motion is responsible for producing almost all of the damaging effects of earthquakes, except for surface-fault rupture. The intensity of ground motion or shaking that could occur at LLNL as a result of an earthquake is related to the size of the earthquake, its distance from LLNL, and the response of the geologic materials beneath LLNL. Ground shaking generally causes the most widespread effects, not only because it propagates considerable distances from the earthquake source, but also because it may trigger secondary effects from ground failure and water inundation. Potential sources for future ground motion at the LLNL Main Site include the major regional faults, as well as the local faults. (DOE 2005)

A recent U.S. Geological Survey (USGS) study of the likelihood of major earthquakes in the San Francisco Bay Area has determined that there is a 62 percent probability of one or more earthquakes with a magnitude of 6.7 on the Richter Scale or greater occurring within the next 30 years. The study concluded that the probability of these earthquakes occurring along the Calaveras and Greenville faults, and the Mt. Diablo Thrust Fault within the next 30 years was 11 percent, 3 percent, and 3 percent, respectively. The study calculated that there was a 50-percent chance of the Livermore area exceeding a ground shaking of Modified Mercalli (MM) intensity VII to VIII. The Association of Bay Area Governments has mapped the distribution of ground-shaking intensity. A large earthquake on the Greenville Fault is projected to produce the maximum ground-shaking intensities in the Livermore area with intensity ranging from strong (MM VII) to very violent (MM X). The MM IX level is associated with damage to buried pipelines and partial collapse of poorly built structures. (DOE 2005)

Seismic hazard analyses have been performed for the LLNL Main Site to quantify the hazard. The analyses identify the probability of exceeding a given peak ground acceleration. The frequency of the design-basis earthquake (DBE) for the Waste Storage Facilities required by DOE-STD-1020-94, Change Notice 1 (DOE 1996) is 1×10^{-3}/yr. The maximum horizontal peak ground acceleration at the Livermore Site for return periods of 1,000 years is 0.57g (DOE 1996). DOE-STD-1020-2002 (DOE 2002) modified the criteria for PC-1 and PC-2 evaluations compared to DOE-STD-1020-94, Change Notice 1 (DOE 1996). The new criteria are based on the 2000 IBC rather than the 1997 UBC. The differences in the two building codes are minor (Coats 2004). Executive Order 12941, "Seismic Safety of Existing Federally Owned or Leased Buildings," references the 2000 IBC, and requires reevaluation of structural integrity under certain circumstances. Based on a seismic screening and evaluation of conditions conducted as required by Executive Order 12941, and the minor changes to the code, none of the RHWM facilities meet the criteria requiring reevaluation (Coats 2004). The potential for surface faulting within the LLNL Main Site is very low, although the potential for surface faulting does exist south of the LLNL Main Site. Based on the fairly deep groundwater levels, the uniformly distributed, poorly sorted sediments beneath the site, and a relatively high degree of sediment compaction, the potential for damage from liquefaction (saturated soil behaves like a fluid from shaking) at the LLNL Main is quite low. Insignificant potential for seismically induced landslides exists at the Livermore Site because of the relatively flat land surface (DOE 2005).

1.5.2 Floods

The Waste Storage Facilities are located above the 100-yr flood plain (DOE 2005). The design-basis flood (DBFl) for a performance category 2 (PC-2) facility at LLNL has a return period of 2000 years (DOE 2002). The two sources of flooding at LLNL are from the Arroyo Las Positas and the Arroyo Seco.

The Arroyo Las Positas approaches LLNL from the east and travels around the site along the eastern and northern borders. A storm flood study was conducted for the DWTF based on historical data and the local surrounding area (Lin 1998). The overflow of this Arroyo during a 2,000 year flooding event has been estimated to impact the DWTF with floodwater approximately nine inches above the existing grade of the DWTF site. The conclusions show no major flood damage to buildings within the DWTF from a 2,000 year frequency precipitation event.

The Arroyo Seco drains the foothills to the southeast and is present for about 900 linear feet in the far southwest corner of the Livermore Site. A Flood Hazard Analysis was conducted for Building 231 Vault (Majumdar 2001). B231 is a PC-2 structure located closer to Arroyo Seco than A625 and is also at a lower elevation than A625. The analysis concludes that a 2,000-year flooding event will not impact the

B231 facility safety or operational safety. Therefore, A625 is also expected to have no major flood damage to buildings from a 2000-year flood.

1.5.3 Wind

The design-basis wind (DBW) for a PC-2 facility at LLNL is 72-mph at 10-m above ground (DOE 1996). Buildings in the DWTF Storage Area and B625 in A625 are designed and constructed to withstand the effects of a PC-2, 72-mph fastest mile wind at 10-m above ground (DOE 1996). DOE-STD-1020-2002 (DOE 2002) modified the wind criterion for PC-1 and PC-2 evaluations. The new criterion is based on a “peak gust” condition rather than “fastest mile” condition. Codes and standards have been changed to reflect the use of “peak gust” wind speeds with the intent of keeping design loads essentially the same (Coats 2004). In addition, the total seismic loads are typically significantly greater than the wind loads for structures in the Waste Storage Facilities.

1.5.4 Lightning

The Livermore Valley rarely experiences severe weather. Thunderstorms occur fewer than 10 days per year and are typically not intense. Over a 10 year period (1991 to 2000), only four lightning strikes were recorded within a 2 mile radius of LLNL. There were no recorded instances of lightning strikes within the boundaries of LLNL during this 10 year period.

1.6 External Man-made Threats

As noted in Section 1.3.1, the nearest public airport to LLNL is the Livermore Municipal Airport, which is located 6.5 miles west of the site. The airport primarily services single-engine aircraft, with some use by twin-engine aircraft and corporate jets. Accordingly, Chapter 3 must address the issue of a small aircraft crash into the Waste Storage Facilities. High voltage power lines run overhead across the A625 yard. This hazard is analyzed in Chapter 3.

1.7 Nearby Facilities

Nearby facilities considered in the hazard analysis include the National Ignition Facility, located approximately 800-feet to the south of the DWTF Storage Area, and B691, located 600-feet to the southeast. Also, the B697 consolidated waste accumulation area/Chemical Exchange Warehouse and the B695 Segment are near the DWTF Storage Area. The facilities located near A625 are Area 612 (A612) to the south, fueling stations to the east, construction equipment and material storage to the south and west, and an office building to the north. The fueling stations (e.g., ethanol, compressed natural gas) are analyzed in Chapter 3. None of the other facilities listed or other facilities at LLNL are likely to impact the Waste Storage Facilities.

1.8 Validity of Existing Environmental Analyses

No significant discrepancies exist or indicate the need to revise the Livermore Site Hazardous Waste Facility Permit (LLNL latest revision). Variations exist in the DSA hazard and accident analysis assumptions for radioactive waste relative to the assumptions used in the 2005 LLNL EIS (DOE 2005) for which a Record of Decision was signed in November 2005 (FR 2005). The Facility Safety Plans will control operations to be consistent with the assumptions used in the 2005 LLNL EIS or superseding documents.

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CHAPTER 2
FACILITY DESCRIPTION

2.1 Introduction

Regional access to LLNL is primarily from Interstate 580 by the Vasco Road interchange. The LLNL site is accessed by security gates along Vasco Road (West Gate), East Avenue (South Gate), and Greenville Road (East Gate).

This chapter describes the structures, operations, confinement systems, safety support systems, utility distribution systems, and auxiliary systems for the Radioactive and Hazardous Waste Management Division's (RHWM) waste storage facilities located at the Lawrence Livermore National Laboratory (LLNL) Main Site (Site 200). The information will also be used to evaluate potential accidents associated with operations, natural phenomena, and external events related to the RHWM Waste Storage Facilities.

The RHWM Waste Storage Facilities are located in two portions of LLNL. A625 is located in the southeast quadrant of LLNL and includes B625, two tents, and associated yard areas. The DWTF Storage Area, which includes Building 693 (B693), Building 696 Radioactive Waste Storage Area (B696R), and associated yard areas and storage areas within the yard, is located in the northeast quadrant of LLNL in the DWTF complex.

These facilities are used by RHWM to handle and store hazardous waste, transuranic (TRU) waste, low-level waste (LLW), mixed waste, combined waste, nonhazardous industrial waste, and conditionally accepted waste generated at LLNL. In addition, several minor treatments processes (e.g., size reduction and decontamination) are carried out in these facilities.

Figure 2-1 shows the A625 footprint and identifies the facilities located in this area. **Figure 2-2** shows the DWTF Storage Area footprint and identifies the facilities located in this area. Section 2.4 describes each of the storage facilities and includes major systems and design criteria.

Figure 2-1. Area 625 Facilities

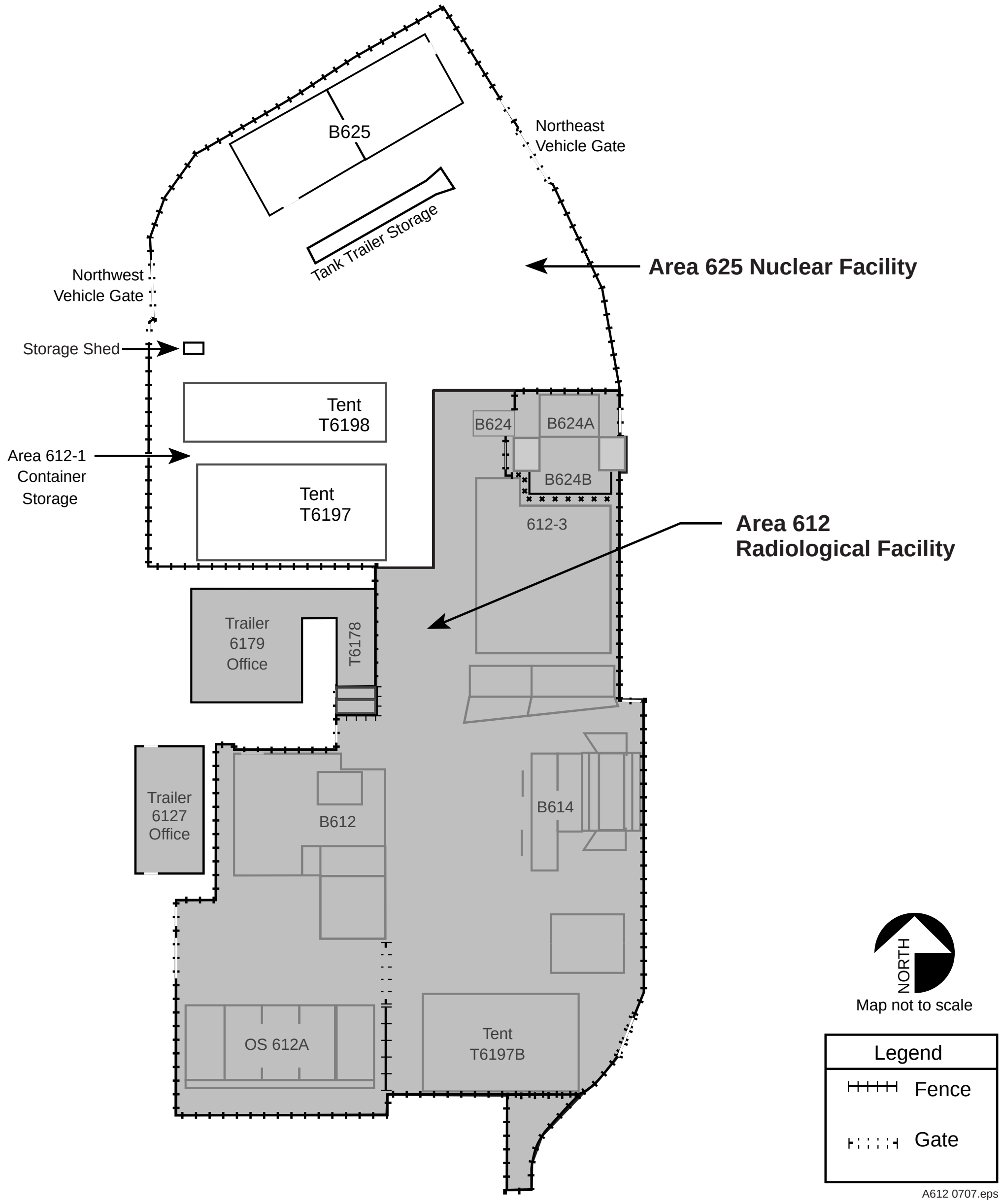
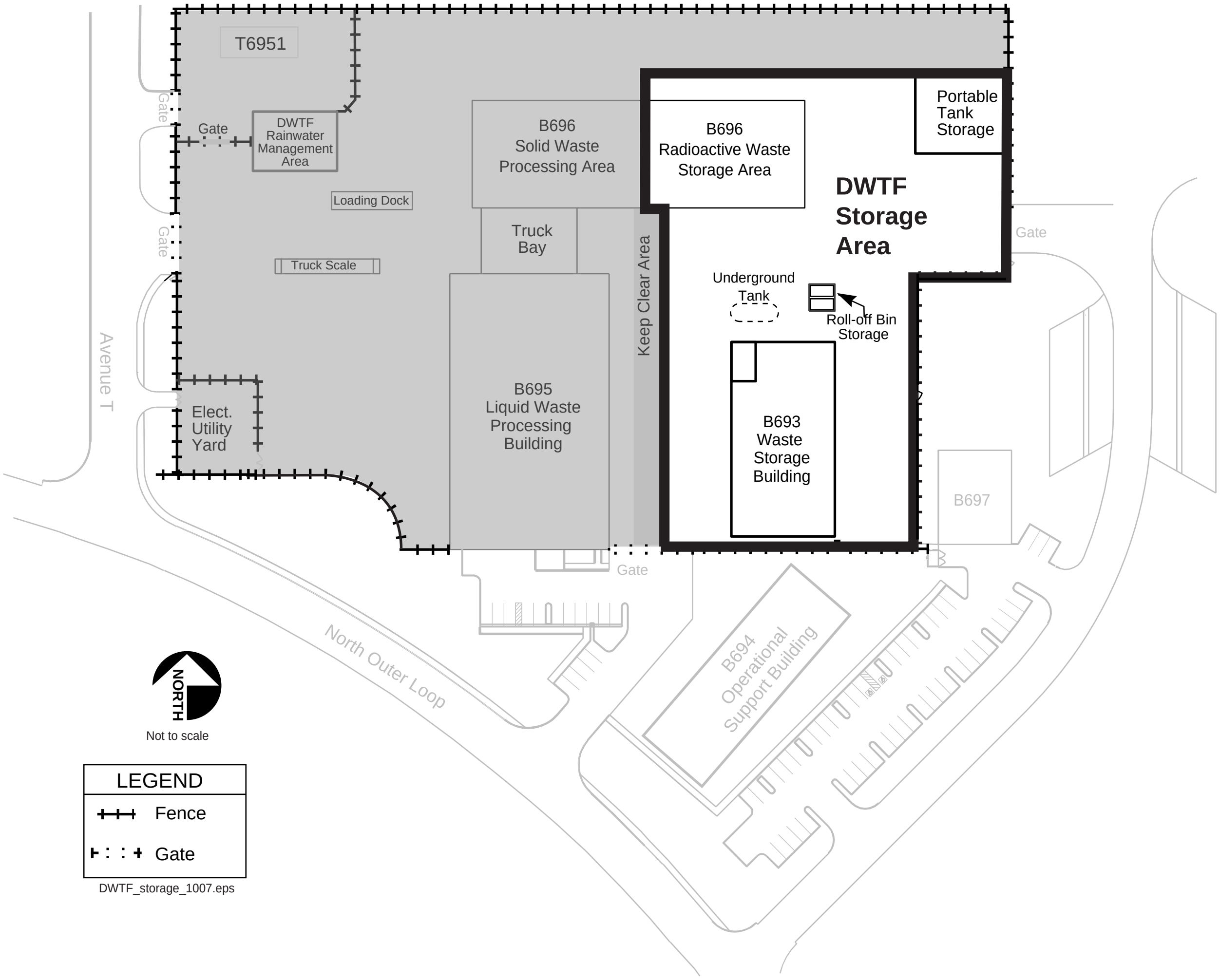


Figure 2-2. DWTF Storage Area in the DWTF Complex



2.2 Requirements

Waste storage facilities are operated to conform to applicable laws and regulations, applicable DOE guidelines, NNSA/LLNS Contract (NNSA/LLNS), and LLNL requirements. A list of key requirements is provided below.

U.S. Department of Energy

DOE O 5400.5, Change Notice 2	Radiation Protection of the Public and the Environment (1993)
DOE O 440.1A	Worker Protection Management for DOE Federal and Contractor Employees (1998)
DOE O 5480.19, Change Notice 2	Conduct of Operations Requirements for DOE Facilities (2001)
DOE O 5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities (1994)
DOE O 435.1	Radioactive Waste Management (1999)
DOE O 420.1A	Facility Safety (2002)
DOE-STD-1020-94, Change Notice 1	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities (1996)
DOE-STD-1020-2002	Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities (2002a)
DOE-STD-1021-93, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Performance Categorization Guidelines for Structures, Systems, and Components (2002b)
DOE-STD-1022-94, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Characterization Criteria (2002)
DOE-STD-1023-95, Change Notice 1, reaffirmed 2002	Natural Phenomena Hazards Assessment Criteria (2002)

Code of Federal Regulations

10 CFR 820	Procedural Rules for DOE Nuclear Activities (10CFR820)
10 CFR 830, Subpart A	Quality Assurance Requirements (10CFR830A)
10 CFR 830, Subpart B	Safety Basis Requirements
10 CFR 835	Occupational Radiation Protection (10CFR835)
29 CFR 1910	Occupational Safety and Health Standards (29CFR1910)
40 CFR 264	Standards For Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities

California Code of Regulations

22 CCR 66264	Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities

California Environmental Protection Agency

Permit Number 99-NC-006	Hazardous Waste Facility Permit for Lawrence Livermore National Laboratory (Main Site)

LLNL Manuals and Reports

UCRL-MA-133867	LLNL *Environment, Safety, and Health Manual* (LLNL latest revision)

2.3 Facility Overview

As briefly described in Section 2.1 above, the RHWM Waste Storage Facilities are in two locations at LLNL. The locations are designated A625 and the DWTF Storage Area. Each of these locations is further subdivided into facilities and storage areas, which consist of buildings, tents, other structures, and open areas.

Current and Historical Use of Facilities

All of the facilities and areas covered by this DSA are used for storage of containerized waste typically generated at LLNL. The types of waste include hazardous waste, TRU waste, TRU mixed waste, LLW, mixed waste, combined waste, nonhazardous industrial waste, and conditionally accepted waste (e.g., special packaging, animal research, pharmaceutical, and medical waste). Some TRU wastes may contain materials considered hazardous by California, but these containers are labeled and stored the same as regular TRU waste and will not be differentiated in this document. The California Environmental Protection Agency Department of Toxic Substances Control (DTSC) under the Resource Conservation and Recovery Act (RCRA) permits portions of these facilities for storage of hazardous and mixed waste (DTSC Permit Number: 99-NC-006 Hazardous Waste Facility Permit for LLNL Livermore Site).

The LLNL site was farmland. During World War II, it was used as a Navy airbase for training. Operations as a nuclear weapons research lab began in 1952. A625 has been used for waste storage since approximately 1962. Building 693 of the DWTF Storage Area has been used for waste storage since approximately 1993. Building 696R of the DWTF Storage Area has been used for waste storage since 2002.

Projected Future Use of Facilities

The facilities and areas covered by this DSA will continue for the foreseeable future to be used for the storage of containerized waste generated at LLNL, as well as small amounts generated at other facilities.

Basic Processes Performed in Facilities and Areas

As stated earlier, the facilities and areas in A625 and the DWTF Storage Area are predominately used for the storage of containerized waste generated at LLNL. All facilities and areas are permitted by DTSC to store and treat hazardous and mixed waste. Some facilities are appropriate only for solid waste; others can store both solid and liquid waste. **Table 2-1** provides an overview of the types and forms of waste stored in the various facilities and areas of the RHWM Waste Storage Facilities. Some facilities are broken down to the room level because of different waste types allowed within the facility.

Waste is accepted into the RHWM Waste Storage Facilities based on information provided by the generators. Waste must satisfy waste acceptance criteria established by RHWM that reflect the criteria provided by disposal sites. Some portion of waste, excluding TRU and mixed TRU, is sampled and analyzed to verify generator knowledge. In order to ensure that the Waste Isolation Pilot Plant (WIPP) waste acceptance criteria (WAC) are satisfied, TRU and mixed TRU will be analyzed using noninvasive (e.g., radiography, radioassay) techniques prior to shipment to WIPP as necessary. It is recognized that due to changing WIPP WAC requirements, waste that predated the WIPP WAC requirements and waste verification activities, some stored TRU waste may deviate from the current WAC requirements. These deviations from the WAC do not represent an increased risk over that postulated in the bounding accident.

Table 2-1. Summary of Allowable Waste Types*

Waste Type Facility	Haz.	Mixed LLW	TRU	Mixed TRU	Liquid	Solid	Flam. Liquid
B625	X	X	X	X	X	X	
A612 Tank Trailer Storage	X	X			X		
A612-1 including T6197 & T6198	X	X				X	
B693, Room 1000	X	X			X	X	X
B693, Rooms 1004, 1008, 1012, 1014	X	X			X	X	
B693 Freezer (Room 1016)[1]	X	X			X	X	
B693 Roll-off Bin Storage	X					X	
DWTF Portable Tank Storage	X	X			X	X	X
B696R	X	X	X	X	X	X	

* Any area within the Waste Storage Facilities fencelines can be used to store non-hazardous (industrial), low-level radioactive, and combined (low-level plus California-only hazardous) waste.

Haz. Hazardous waste (gaseous waste can be stored in any facility permitted to be used for hazardous waste).

Flam. Flammable liquid waste.

X Commonly stored or allowed for this waste type.

1. May be used to store items such as animal cadavers and medical waste.

2.4 Facility Structure

This section provides an overview of the buildings, structures, and areas in the RHWM Waste Storage Facilities, including construction details such as basic floor plans, equipment layout, construction materials and structural dimensions. Pertinent information related to the structure and the general arrangement of the facilities are extracted for the hazard and accident analysis. Although an effort has been made to use consistent terminology for describing facilities and areas, there are alternate names that have been used primarily in the Operation Plan (RCRA Permit). Many of the storage areas are known as Container Storage Units (CSUs) in the Operation Plan. In general, this DSA does not use this nomenclature.

2.4.1 List of Facilities and Areas

Following is a list of the storage facilities covered by this DSA:

Area 625

1. Building 625 **(Figure 2-3)**
2. Area 612 Tank Trailer Storage **(Figure 2-4)**
3. Area 625 (outside south of B625)
4. Area 612-1 **(Figure 2-5)**
    a. Tent 6197
    b. Tent 6198
    c. Asphalt pad

DWTF Storage Area

1. Building 693 **(Figure 2-6)**
2. B693 Roll-off Bin Storage Unit **(Figure 2-2)**
3. DWTF Portable Tank Storage Unit **(Figure 2-2)**
4. DWTF Underground Tank **(Figure 2-2)**
5. Building 696 Radioactive Waste Storage Area (B696WSA) portion of B696 **(Figure 2-7)**

2.4.2 Basic Floor Plans of Facilities

Following are floor and plot plans for the facilities and areas covered by this DSA. Where appropriate, equipment footprints are located within the floor plans. Key dimensions are included on the floor plans.

Figure 2-3. Building 625

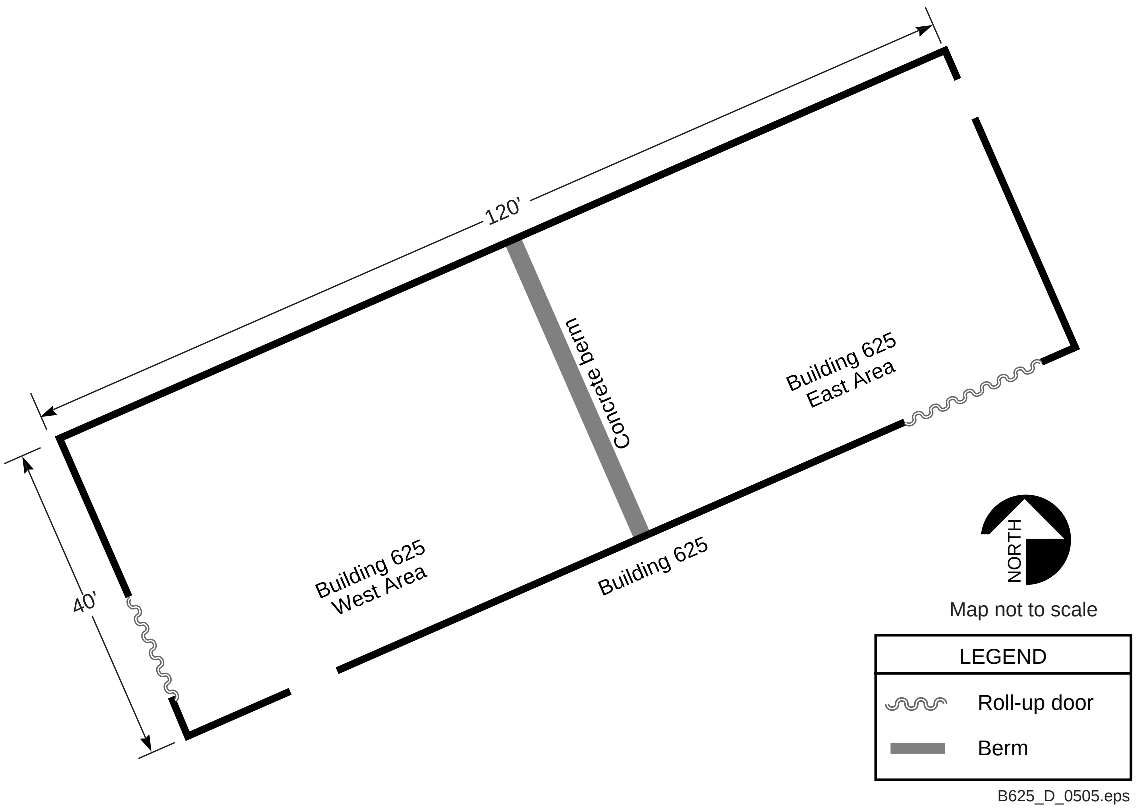


Figure 2-4. Area 612 Tank Trailer Storage

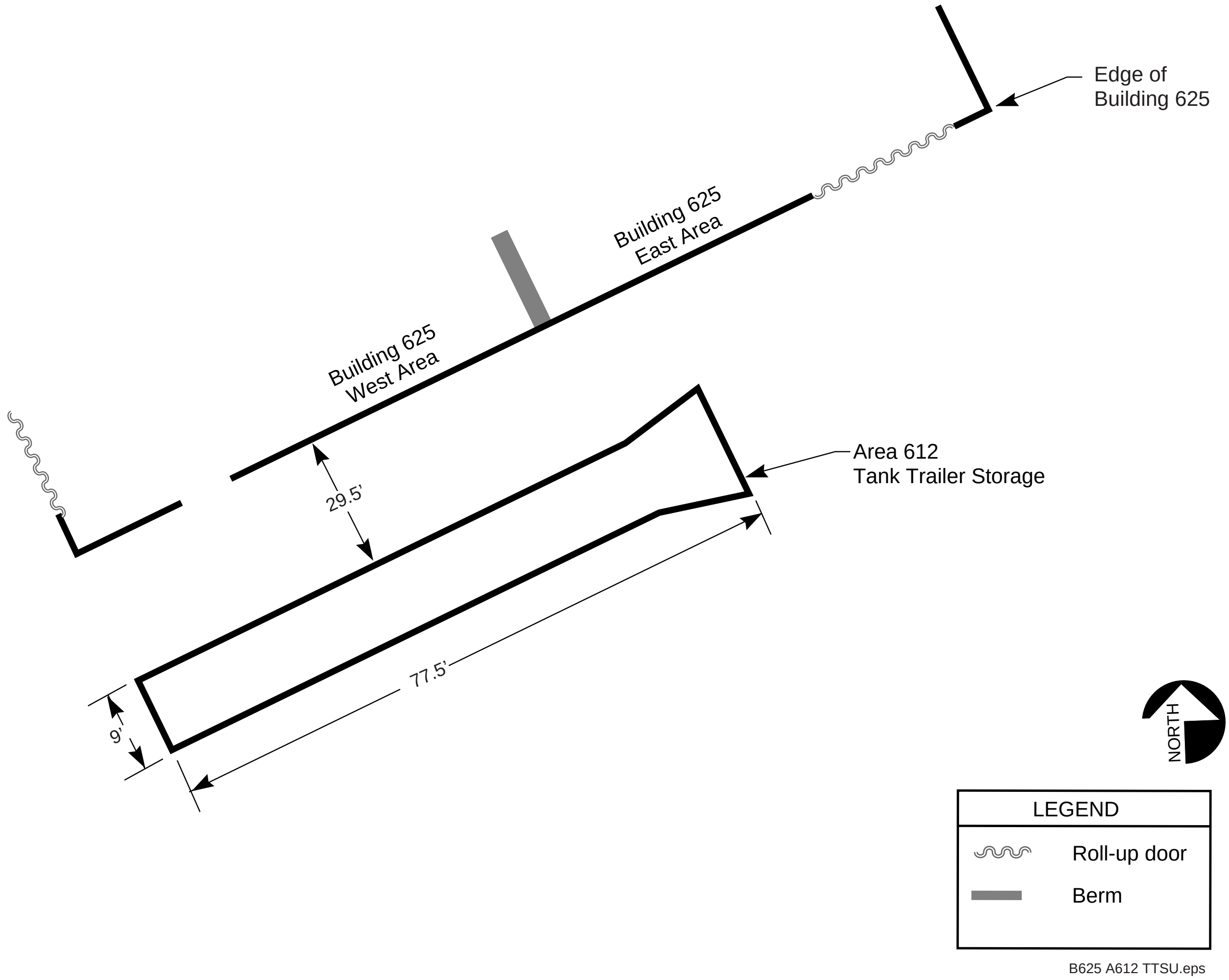


Figure 2-5. Area 612-1

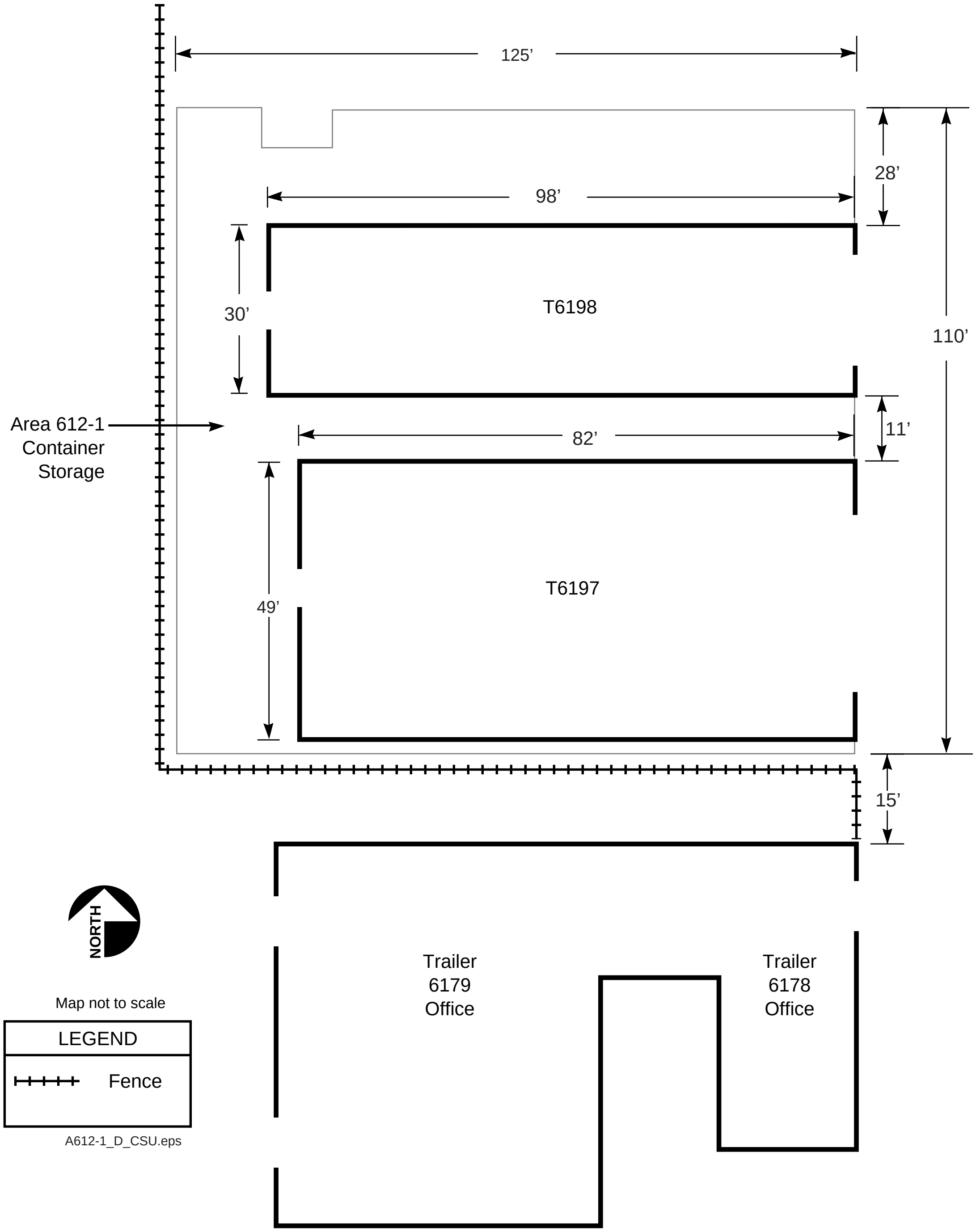


Figure 2-6. Building 693

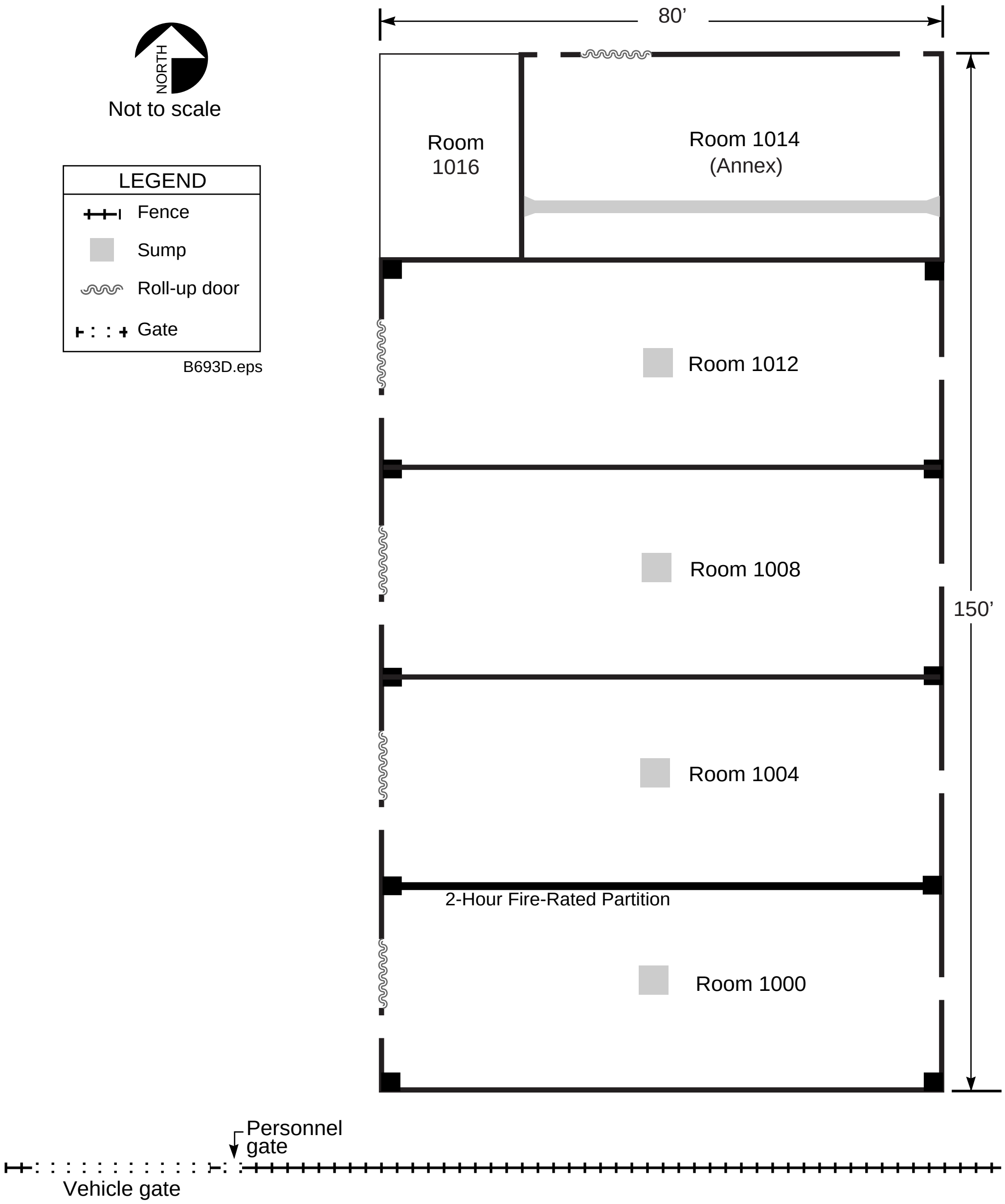
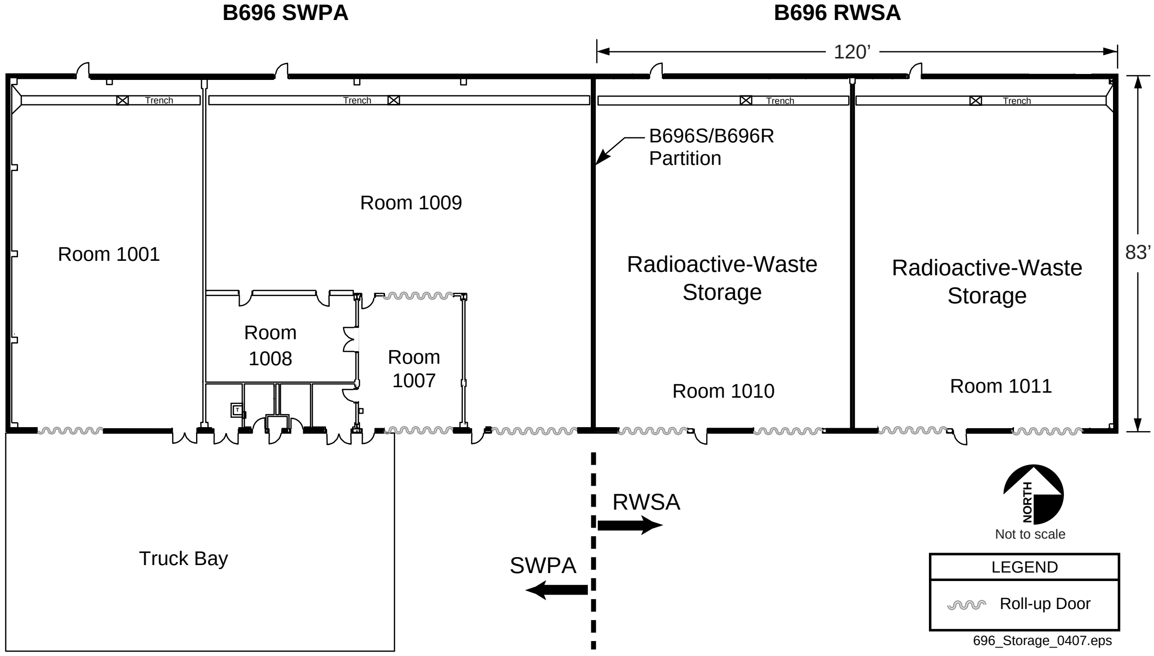


Figure 2-7. Building 696



2.4.3 Dimensions Significant to Hazard and Accident Analysis

The dimensions most significant to hazard and accident analysis activities are the distance from the facility to the nearest LLNL site fenceline and the overall size of the facility (applicable to roofed facilities). Dimensions of tents are not included. The closest fenceline in all cases is the Greenville Road fenceline, to the east. **Table 2-2** provides these distances.

Table 2-2. Building Dimensions

Facility	Distance to fenceline, m	Height, ft	Width, ft	Depth, ft
B625	250	24	120	40
A612 Tank Trailer Storage	260	NA	77.5	9
A612-1 including T6197 & T6198	260	NA	NA	NA
B693	130	16	150	80
B693 Roll-off Bin Storage	130	NA	NA	NA
DWTF Portable Tank Storage	90	NA	NA	NA
B696R	140	23	120	80
Facility boundary fence nearest site fenceline (E. of B693)	90	NA	NA	NA

2.4.4 Construction Material

As will be described in a subsequent section, some of the facilities are built to meet PC-2 requirements, designed to protect the waste from being seriously damaged in an earthquake or high wind. The structural systems that are important for maintaining the PC-2 rating for the B625 and B696R facilities consist of the following:

- Foundations
- Columns
- Beams directly connected to the columns
- Lateral bracing
- Crane support/restraints (for B625 only)
- Roof deck

Table 2-3 provides a summary of construction materials employed in the facilities covered by this DSA.

Table 2-3. Construction Material used in Waste Storage Facilities

Facility	Roof	Ext. walls	Int. wall(s)	Floor	Floor covering	Berms
B625	metal	metal	none	concrete	epoxy	concrete
A612 Tank Trailer Storage	none	concrete	none	concrete	epoxy	concrete
Tents 6197and 6198	PVC-coated polyester	PVC-coated polyester	none	asphalt	none	none
B693	metal	concrete	gypsum	concrete	epoxy	concrete

		block & metal				
B693 Freezer Pad (Room 1016)	metal	none	none	concrete	none	none
B693 Roll-off Bin Storage Unit	none	none	none	concrete	none	none
DWTF Portable Tank Storage Unit	none	none	none	concrete	epoxy	concrete
B696R	metal	metal	gypsum	concrete	epoxy	concrete
Yard areas	none	none	none	asphalt	none	none

Note: In all cases where concrete is specified, including concrete block, it is steel-reinforced concrete

2.4.5 Facility Performance Categorization

The RHWM Waste Storage Facilities were built over many years. Some facilities have been upgraded or retrofitted to improve the seismic integrity. All of the facilities were built to meet or exceed the building codes and DOE Orders that were in place at the time of construction or upgrade. The most likely natural phenomena hazard that might affect these structures is earthquake. Seismic evaluations have been performed to verify that the facilities satisfy the requirements for a PC-2 facility, as defined in DOE-STD-1020-94, Change Notice 1 (DOE 1996). The results of these reviews are summarized in **Table 2-4**. None of the RHWM facilities require seismic reevaluation based on DOE-STD-1020-2002 criteria (see Section 1.5.1).

Seismic forces typically generate the governing structural loads, so facilities that meet seismic requirements typically exceed wind criteria. California is not known for hurricanes or tornados and DOE-STD-1020-2002 does not require tornado design consideration for PC-2 facilities. Most buildings have calculations specific to maximum wind speed.

Water damage is possible but would not be expected to be severe at LLNL. LLNL is located near some minor arroyos, and no rivers are located within the valley. Flash floods are not expected. **Table 2-4** summarizes information on the facilities.

Table 2-4. Facility Performance

Facility	UBC Year[1]	Seismic / Wind Reference	Meets PC-2 Seismic	Meets PC-2 Wind	Meets PC-2 Flood
B625	1997	LLNL 2000	Yes	Yes	Yes
B693, Rooms 1000-1012	1988	LLNL 1991a	Yes	Yes	Yes
B693, Rooms 1014 & 1016	1997	LLNL 1995	Yes	Yes	Yes
B696R	1994	LLNL 1995	Yes	Yes	Yes

1. UBC in effect when building was designed or when seismic review was performed.

2.4.6 Underground Tanks

DWTF Underground Tank

The 20,000-gal fiberglass-reinforced plastic (FRP) single walled underground tank provides containment for fire sprinkler water from B693 Room 1014, the DWTF Truck Bay, B695 Reactive Waste Storage Rooms, and B697. It will handle approximately 30-minutes worth of fire sprinkler water discharge, depending on the building involved. The tank has a 4-in pump-out connection for removing contents via an extraction truck, a level switch and transmitter, and 2-in vent. The tank is also equipped with a 30-in access way that is accessible via a steel-covered entry hole in a concrete pad. Mounted on the exterior south wall of B696R is the monitoring station to monitor the tank level.

2.5 Process Description

This section provides descriptions of the processes to support assumptions used in the hazard and accident analyses. These descriptions focus on major process features necessary to understand the hazard analysis and accident analysis. This chapter does not designate any Technical Safety Requirement (TSR) controls. That information is provided in Chapter 5.

2.5.1 Waste Storage Operations

The facilities covered by this DSA handle the following waste types:

- Nonhazardous industrial waste
- Hazardous waste
- Transuranic (TRU) waste
- Low-level waste (LLW)
- Mixed waste
- Combined waste (LLW that contains California-only regulated hazardous constituents above the regulatory limit)
- Conditionally accepted waste (e.g., special packaging, animal research, pharmaceutical)

The following summarizes general waste storage operation and waste handling activities occurring in these facilities:

- Moving, staging, or storing containerized waste.
- Segregating waste according to compatibility.
- Opening containers of waste, except TRU or mixed TRU, for activities such as inspection, sampling, sorting, segregating, or repackaging.
- Waste sampling activities, including preserving samples, decontamination of nondisposable sampling equipment, pH and flashpoint testing.
- Overpacking or repackaging.
- Encapsulating, packing and otherwise preparing sealed sources for shipment.

- Surveying and assaying waste containers, e.g., gamma spectrometry, nondestructive assay (NDA) techniques.
- Radiography.
- Counting radioactive swipes samples.
- Inspecting integrity of waste containers and container storage areas (daily and weekly when-in-use inspections).
- Bulking and transferring waste, except TRU or mixed TRU.
- Container maintenance (e.g., painting, replacing gaskets on portable tanks, adding and removing labels).
- Relieving pressure from over-pressured drums except for TRU or mixed TRU waste containers.
- Decontamination of equipment except that equipment designated as TRU or mixed TRU.
- Dismantling and size reduction of equipment except equipment designated as TRU or mixed TRU.
- pH adjustment of aqueous non-hazardous waste for sewer discharge; discharge of waste effluent to the sanitary sewer.
- Transport of waste containers within the DWTF and A625 using vehicles, including trucks and forklifts, and manual means such as drum dollies.
- Movement of waste containers within the buildings and other structures using forklifts and manual means such as drum dollies.
- Receiving containers from and shipping containers to facilities outside of DWTF and A625 using vehicles.
- Storing sealed sources, for example, plutonium and uranium standards, for use in calibration and testing of radioassay equipment; assembling and disassembling samples consisting of these standards placed into containers, such as drums; inventorying and leak testing them.

The discussion in this section focuses on the general waste storage operation and waste handling activities that are common throughout the storage facilities covered by this DSA. Additional activity and process descriptions are provided in subsequent sub-sections for facility-specific activities, such as the TRU Thermal Conditioning and the trailer-mounted NDA unit.

In general, the waste containers used at LLNL range in size from 1 ml to 20,000 gal and include cans, bags, vials, jars, bottles, drums, boxes, carboys, portable tanks, and tank trucks. Occasionally containers as large as transportainers are used. All containers, portable tanks, liners, and over-packing material used at LLNL are selected for their compatibility with the wastes. Liquid wastes are typically stored in metal, plastic, or glass containers. Solid waste and waste that does not contain free liquids can be stored in cellulose containers as well as metal, plastic, or glass containers. Metal cylinders are used to store gaseous waste or liquefied gas waste. Compatible containers are used to store flammable and combustible liquids in areas designated for such storage. Waste containers are staged and stored on metal, plastic, or wood pallets. TRU waste is stored on metal pallets only.

TRU waste is stored in TRU waste containers that satisfy the free drop test performance criteria for steel 7A Type A packaging [49 CFR 173.465(c)(1)]. In the past, TRU waste containers were procured by DOE contractors (including LLNL) and some containers did not have the appropriate documentation indicating they met performance criteria for 7A Type A packaging. Subsequently, these containers were subjected to performance testing under separate testing programs to determine if they did meet the 7A Type A packaging performance criteria (specifically the 4-ft drop criteria). Results from the DOE-sponsored 7A Type A Testing Program are documented in the DOE *Test and Evaluation Document for DOT Specification 7a Type A Packaging*, DOE/RL-96-57, Volumes 1 and 2 (DOE/RL 1996). The tests showed that LLNL's TRU waste containers did meet the free drop test performance criteria for Type A packaging. In the 1990s, LLNL began procuring containers for TRU waste that were documented as meeting the free drop test performance criteria for 7A Type A packaging [49 CFR 173.465(c)(1)], using the Packaging and Transport Department procurement process. Therefore, all of the TRU waste in RHWM is packaged in containers that meet the free drop test Type A packaging performance criteria [49 CFR 173.465(c)(1)].

Most approved TRU waste containers are vented with carbon-media filter vents to prevent the buildup of gases. The remaining approved TRU waste containers, specifically TRU Oversize Boxes, are not fitted with vents. However, the gasket area between the lid and the box may provide some venting of gases. There are some steel Type A drums that were accepted as containing LLW but on assay reclassified as TRU (LLW/TRU conversions) that are unvented. The waste disposal requisition (WDR) for LLW/TRU conversions will be updated to reflect the change in waste characterization and the containers will be moved into an approved TRU storage area. These drums may be relocated to another facility to have a vented lid replacement or may be placed into a larger container with a vent. LLW is stored in a variety of containers, including, but not limited to, metal boxes and drums, plastic drums and bags, large metal transportainers, plastic tanks, wood crates, and fiber boxes.

Containers can arrive at the storage facilities either by truck or forklift, either from other RHWM facilities, other DOE facilities, or from the generator. The containers are secured to the vehicle using RHWM tie-down procedures when transported outside the fenced waste areas. Forklifts are generally used to move waste containers from trucks to staging areas, storage areas, or into storage buildings. Forklifts may also be used to move waste within the A625 or DWTF.

The transport of containers is performed in accordance with the LLNL *Onsite Packaging and Transportation Safety Manual* (LLNL latest revision) and the LLNL *Nuclear Materials Transportation Safety Manual* (LLNL 2005), which establish LLNL policy for the onsite transfers of hazardous and radioactive materials, substances, and wastes within LLNL. The topics covered by this manual that are relevant to waste handling include:

- Responsibilities of RHWM Division personnel
- Securing containers during transportation
- Requirements for vehicles transporting radioactive or hazardous waste.

Containers are transported manually (e.g., carried, drum dolly) or by forklift. Drums and smaller containers moved by forklifts are handled using a forklift attachment or placed on pallets for moving a group of containers. Some containers, such as portable tanks and boxes, have skids that are designed to be transported by a forklift. Pickup and flatbed trucks are also used to transport containers. Containers and pallets are secured to the bed of the truck prior to transport. Operator training and traffic controls minimize the potential for spillage and accidents.

Liquid waste is normally transported in containers, portable tanks, and tank trucks. All containerized liquid waste (including waste containing free liquids) is stored in secondary containment.

Containers are kept closed except when empty or when wastes are being added or removed (not applicable to TRU waste) as in sampling, bulking, pH adjustment, repackaging, or lab packing operations. However, some waste containers may need to be vented to prevent pressure build-up and/or flammability hazards. TRU waste containers are vented to allow for the dissipation of hydrogen gas resulting from the radiolysis of plastic waste materials. Containers of hydrogen peroxide may be vented using plugs that prevent the escape of liquids. When required either to comply with air emission requirements (e.g., 40 CFR 264 Subpart CC) or to prevent other types of releases (e.g., radionuclides), such as required by the DOE Waste Isolation Pilot Plant Waste Acceptance Criteria (WAC), the container vents are fitted with carbon and/or high-efficiency particulate air (HEPA) filters.

Gas cylinders are stored in a manner that minimizes the likelihood of rupture should the cylinder be dropped, tipped, or hit by a heavy falling object. For example, a gas cylinder may be secured in an upright position, strapped to a pallet in a horizontal position, or overpacked in an approved container. When not in use, cylinders are firmly capped.

Different waste types are often stored in the same facility. As an example, hazardous, mixed and TRU waste might be placed in a room together. In general in the Waste Storage Facilities, there may be differences in how the waste is stored such as the pallets used (e.g., hazardous and low-level waste on metal and plastic pallets). However, in rooms storing TRU waste, only waste in metal containers and on metal pallets is allowed.

Waste staging involves placing containerized waste in the yard area (outside of a storage area), and is usually performed when waste is being received, moved from one location to another, or prepared for shipment. Waste may also be staged when maintenance is being performed in a storage area. Staging is temporary, and hazardous and mixed wastes are subject to time constraints described in the RCRA Operation Plan. Staged waste is posted as staged. Low-level radioactive waste may be stored in the same areas (any place inside the Waste Storage Facilities).

With the exception of TRU waste, containers can be opened for sampling or other waste handling activities. The work authorization control program assures that either sampling procedures, processing plans, work permits, and/or integration worksheets are used to implement controls and monitoring when required. Chapter 9 discusses protocols for developing and implementing controls and monitoring of waste handling activities.

Lab packing, overpacking, and repackaging activities are performed throughout the Waste Storage Facilities. TRU waste is not lab-packed or repackaged. Lab packing involves placing a number of small waste containers into one single container. Even though each waste remains in their small container, only compatible wastes may be lab packed together. Overpacking usually involves placing one container of waste into another larger container. However, numerous large containers of waste may be overpacked into a transportainer. Repackaging involves removing waste from its original container and placing it into another container.

Containerized wastes are also subject to surveying, assaying, and radiography. Surveying determines the level of radiation at the container surface or some distance from the container using portable hand held equipment. Assaying determines the type and quantity of radionuclides in the waste. Portable or stationary equipment may be used. A Non-destructive Assay (NDA) unit is used in the facilities to measure small containers. A Gamma Spectroscopy System is a portable assay unit that is also used in the storage areas covered by this DSA. A trailer-mounted NDA may be used to assay radioactive waste in either waste storage area. Radiography uses x-rays to inspect the contents of waste containers. This is used to verify the physical form of the waste, ensure the waste matches the waste stream description, and identify prohibited items.RHWM container storage areas are inspected each work day to ensure that waste containers are in good condition. Containers that are found to be damaged, deteriorated, or leaking are managed in accordance with applicable procedures. Visual inspections are used to determine if liquids have accumulated in any of the facility sumps. Equipment is used to remove accumulated liquids.

Unvented TRU Oversize Boxes and unvented TRU drums (LLW/TRU conversions) are visually inspected for bulging, an indicator of possible flammable gas buildup. Although some methane is produced from radiolysis of organics, the major product is hydrogen. Hydrogen also has the wider flammability range of the two and is thus used to bound accident scenarios.

Inspection results may indicate the need for container maintenance to be performed to ensure a container's integrity. Examples of container maintenance are painting, replacing gaskets on portable tanks, and adding/removing labels.

Waste effluent is discharged to the sanitary sewer through an access port in the A625 yard. Prior to the discharge of aqueous waste to the sanitary sewer, the pH may need to be adjusted to meet discharge requirements. If the pH adjustment does not constitute treatment (as defined by RCRA), this activity may occur anywhere in the A625 or DWTF yard.

Equipment decontamination or dismantling may also be performed anywhere in the yard of A625 or the DWTF, as long as these activities do not constitute treatment as defined by RCRA. These activities may include use of manual, electric, and pneumatic tools, such as saws, shears grinders, and impact wrenches; flammable gas torches and plasma cutters; and other standard equipment used for such purposes.

2.5.2 Trailer-mounted Nondestructive Assay (NDA) System

A trailer mounted NDA unit will be used in A625 and DWTF to quantify the radionuclides in waste containers. The trailer will be moved in by truck (tractor) and set up in a suitable location to keep from interfering with normal waste movement. The trailer-mounted NDA does not contain a radiation-generating device. Electrical connections will be made to supply the NDA equipment. Containers of waste are loaded and unloaded from the NDA trailer using forklifts.

2.5.3 TRU Waste Container Thermal Conditioning

TRU and mixed TRU waste is thermally conditioned prior to headspace gas sampling as part of the characterization process required to certify waste for shipment to the WIPP for disposal. Thermal conditioning involves maintaining containers at a minimum temperature of 65°F for an established period of time. Blanket heaters are used to thermally condition TRU and mixed TRU in B625 and B696R. These blankets are electrically heated and thermostatically controlled.

2.5.4 Cranes

A 3-ton overhead bridge crane system is located in B625. The B625 bridge crane is used for moving large waste containers, such as Standard Waste Boxes (SWBs), equipment or for picking containers from storage arrays. Personnel using the cranes are trained in their operation. The crane is comprised of a trolley assemblage, hand control unit, crane unit, crane girders, and 3-ton hoist. The unit spans about 40 feet in a north-south orientation. The crane unit travels the length of the building (in an east to west direction), and is controlled by a hand unit connected to the crane. The crane has been retrofitted with seismic restraints. The seismic restraints were designed to meet DOE-STD-1020-94 PC-2 criteria.

Mobile cranes are also used throughout the Waste Storage Facilities for activities such as moving waste containers, transportainers, and equipment and for maintenance. Hoisting and rigging is performed consistent with established LLNL practices by qualified crane operators.

2.5.5 Maintenance Activities

Maintenance activities are performed in compliance with current DOE orders for maintenance of nuclear facilities where applicable. All maintenance is at least performed similarly to that found in industry using the graded approach. Maintenance activities are primarily performed by RHWM maintenance personnel, Plant Engineering, Utilities and Telecommunications, and Hazard Control. These activities are governed by and must comply with work authorization practices. Examples of maintenance activities include standard building maintenance, such as painting, resurfacing asphalt, re-epoxying floors, welding, filter replacement, and equipment maintenance (e.g., calibration, lubrication, re-builds, parts replacements). Fixed and portable ladders, man lifts, scaffolding and scissor lifts will be used for working at heights. The schedule and type of maintenance for facilities and process equipment is tailored to the facility and to the type of equipment, frequency of use, age, and performance requirements.

Maintenance requires the use of limited quantities of lubricants, solvents, and other combustible/flammable materials in the facility. Welding and other hot work may be performed using the LLNL Hot Work Permit Process. The RHWM Maintenance Program is discussed in Chapter 10.

2.6 Confinement, Containment and Ventilation Systems

This section identifies and describes the set of structures, systems and components that perform confinement, containment and/or ventilation functions.

2.6.1 Waste Containers

Waste containers provide primary confinement for waste material being stored, staged, or handled, thus preventing a significant release of radioactive or hazardous material. Approved waste containers provide the means to package contaminated waste for transport and handling, and are a layer in defense-in-depth to significant releases and to mitigate releases in the event of mechanical impacts or thermal stresses. TRU and mixed TRU waste are stored in approved TRU waste containers.

2.6.2 Floors

All facilities that store hazardous liquid waste have concrete floors with integral concrete berms with the exception of the freezer. Liquids stored in the freezer will be placed in secondary containment. The floors and berms are coated with a sealant to reduce the possibility of spilled liquids reaching the soil under the concrete. All other floors are concrete or asphalt.

2.6.3 Freezer Storage

The freezer is located in B693 Room 1016 on the freezer pad. The industrial grade freezer primarily stores contaminated animal carcasses and other radioactive, biological hazardous and/or non-hazardous waste.

2.7 Safety Support Systems

No active Safety Systems have been identified. Therefore, there are no support systems on which a Safety System relies. The storage facilities covered by this DSA are typically simple structures with few active systems. There are no safety support systems built to a lower standard than the building or a safety significant system as described in DOE-STD-1021-93, Change Notice 1, reaffirmed 2002 (DOE 2002b).

2.7.1 Fire Protection

B625 and B696R have fire sprinkler systems meeting NFPA 13 for Ordinary Hazard occupancies. Both are wet pipe systems.

Building 693 has a fire sprinkler system meeting NFPA 13 for Ordinary Hazard Group 2, except that Room 1000 and 1014 (Annex) are hydraulically calculated to Extra Hazard Group 1. B693 Room 1000 has an automatic high-expansion foam fire extinguishing system that is the primary fire protection provided for flammable waste storage. This system is triggered either by rate compensated heat detectors, or by manual pull stations, and is designed to activate prior to the fire sprinklers, greatly reducing the quantity of water that might be discharged on a fire.

Fire extinguishers are located according to the requirements of NFPA 10, *Standard for Portable Fire Extinguishers*, and where specific fire hazards are present.

2.7.2 Emergency Lighting

All fully enclosed storage buildings (no light from windows or openings) have battery operated egress lights. The egress lights become active when there is a power failure. RHWM also has a portable generator and lights.

2.7.3 Emergency Evacuation/Alarm

A625 and the DWTF are connected to the audible warning system operated by the LLNL Emergency Management System. Speakers adequate to cover the area are mounted both outside and inside facilities. In addition, in B696R a visual warning system is provided to notify personnel to evacuate the building.

2.7.4 Radiation Protection and Warning System

When required, RHWM places portable continuous-air monitors (CAMs) or passive air samplers (PASs) in areas where individuals are performing operations involving opened radioactive-waste containers, such as for drum crushing of radiologically contaminated drums. CAMs and PASs are placed and used in accordance with 10 CFR 835.403, “Area Monitoring.”

2.8 Utility Distribution Systems

The storage facilities are simple structures with minimal, standard utilities. The utilities found in these facilities are electricity, telephones, water, compressed air and in one case, a hot water space heating system (B696R). All facilities have emergency eyewash and shower stations. There are no utilities or attachments built to a lower standard than the building or a safety significant system, a potential concern described in DOE-STD-1021-93. Utilities are periodically modified to meet institutional and operational needs.

The availability of any of these utilities affects neither the storage function nor the operations carried out in these facilities. RHWM has portable generators and lights that can be employed if necessary.

The water to the automatic fire sprinkler systems is provided by a Laboratory-wide distribution system, with three possible sources. The water generally comes from tanks located high enough to provide adequate pressure based on gravity alone. A 12-in asbestos-concrete water main traverses A625 in an east-west line, running along the southern edge of T6197. It is buried approximately 60-in deep. A 10-in asbestos-concrete water main tees from the 12-in main east of B624 and runs north under OS624A south and OS624A north. It is approximately 60-in deep.

High voltage (three phase 115 kV) transmission lines cross A625 in an east-west line, running along the southern edge of T6197. Lower voltage (three phase 13.8 kV) distribution lines cross A625 in an east-west line, running along the southern edge of T6179.

There are underground natural gas pipes traversing both the DWTF Storage Area and A625. The pressure of gas in these lines is no greater than 60 psi, the pressure coming from the PG&E main at East Avenue. A 3-in carbon steel high-pressure gas line crosses in front of B694 and then under the DWTF Storage Area in a north-south line equidistant between B693 and B697 (east of B693). It is capped at depth at approximately 70 ft north of the storage area fence. It is buried approximately 60-in deep and does not come to the surface.

A 12-in carbon steel high-pressure natural gas line crosses A625 in an east-west line, running along the southern edge of T6197. It is buried approximately 56-in deep.

2.9 Auxiliary Systems and Support Facilities

The Waste Storage Facilities are part of the infrastructure of the LLNL Main Site. Thus, all of the auxiliary systems and support facilities expected at a large DOE research facility are available. In addition to the utilities described above, LLNL maintains a contract with Alameda County to provide emergency services on-site; deploying a fully equipped and staffed onsite Fire Department, including ambulances with trained paramedics.

The DWTF complex is fully fenced. The area encompassing the A625 nuclear facility and the A612 radiological facility is also fully fenced. Access is limited to trained RHWM workers, trained and authorized maintenance workers, trained and authorized Hazard Control personnel, and trained and authorized DOE personnel. Others must be under escort.

2.10 References

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CHAPTER 3
HAZARD AND ACCIDENT ANALYSES

3.1 Introduction

This chapter presents the Waste Storage Facilities hazard and accident analysis, which comprises an identification and assessment of hazards, a facility hazard categorization based both on radiological and chemical hazards, and an analysis of potential accidents that could impact the worker, public, and the environment. This analysis was prepared in accordance with DOE-STD-3009-94, Change Notice 3 (DOE 2006) with the primary objective of obtaining a better understanding of the hazards and risks associated with operation of the Waste Storage Facilities. This chapter provides an overview of the safety analysis methodology, a characterization of the hazards, the impacts of bounding accidents, the assessment of risk, and conclusions of the analyses.

Transuranic (TRU) waste, hazardous waste, mixed waste, low-level waste (LLW), mixed TRU waste, liquid waste, solid waste, flammable waste, and combined waste are allowed to be stored in these facilities. A list of California regulated hazardous wastes can be found in the CCR, Title 22. A list of hazardous wastes that may be accepted into the permitted facilities are contained in the RCRA permit and associated operational plan. The main California hazardous wastes stored in the facility are small amounts of solid corrosives, toxic waste containing metals or organics, and some listed wastes. In the first sections, the purpose of these analyses is discussed, and the hazard identification and evaluation methodologies are presented. These sections are followed by the identification of hazards and development of such hazards into hazardous events, assessment of preventive and mitigative features, and the hazard categorization analysis. Postulated hazardous events were evaluated in a qualitative risk assessment to identify important or high-consequence events. Once identified, these events were further analyzed against Evaluation Guidelines in the accident analysis.

The graded approach as applied to these analyses prescribes that an analysis technique be no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility (DOE 2006). Therefore, the analyses presented here were conducted only to the level necessary to provide a technical basis that the facility can be operated safely, with minimal risk to workers, the public, and the environment. Consequently, the presentation largely takes the form of a qualitative analysis, with only the consequences of bounding accidents evaluated quantitatively as appropriate. Where U.S. Environmental Protection Agency (EPA) guidelines and DOE classification criteria could be met easily, the use of bounding assumptions and less-detailed physical modeling and accident analysis was appropriate.

Based upon the analyses reported herein, the Waste Storage Facilities were determined to be Hazard Category 2 nuclear facilities for the radionuclide inventory in accordance with DOE-STD-1027-92, Change Notice 1 (DOE 1997) and a low-hazard classification based on the chemical inventory (as determined by a chemical inventory in accordance with Hildum 2000). It was demonstrated that the design and operation of the Waste Storage Facilities does not adversely impact the health and safety of the workers and the public.

3.2 Requirements

Requirements for the safety basis for the Waste Storage Facilities are established through 10 CFR 830, Subpart B. This chapter follows the format and content guide in DOE-STD-3009-94, Change Notice 3. As part of the safety analysis procedure set forth by DOE, a hazard and accident analysis is performed to characterize the level of intrinsic potential hazards and associated consequences resulting from potential accidents.

3.3 Hazard Analysis

This report is intended to provide the basis for operation of the Waste Storage Facilities. This is accomplished by means of a thorough hazard-identification and hazard-assessment process to evaluate potential process-related consequences resulting from internal, external, and natural phenomena events. The discussion of this hazard analysis includes the following:

Description of hazard analysis methodology

- Identification of hazard sources
- Identification of the radiological and chemical inventory by type, form, quantity, and location
- A radiological hazard categorization in accordance with DOE-STD-1027-92 by a comparison to the radionuclide inventory with threshold values
- A chemical hazard classification through a comparison with reportable quantities, threshold planning quantities, and threshold quantity based on Hildum (Hildum 2000)
- Identification of potential hazardous events and their respective consequences
- Identification of preventive and mitigative features
- Identification of significant worker-safety features
- Identification of defense-in-depth measures
- Assessment of a qualitative likelihood of occurrence of hazardous events in combination with potential consequences to estimate the risk associated with design and operation of the facility

Because the operations performed within the Waste Storage Facilities are not complex, e.g., the storage and handling of TRU waste, hazardous waste, LLW, and combined waste in containers, the graded-approach concept to hazards analysis is employed.

3.3.1 Methodology

The Process Hazard Analysis (PrHA) methodology was devised to identify and characterize hazards and to perform a systematic evaluation of hazardous events. This methodology is used to develop, based on the hazard analysis team's knowledge and experience with the area's systems and operations, accident scenarios involving the identified hazards. Application of the methodology does not require detailed system information or exhaustive development of accident sequences. Instead, facility equipment, material, environmental factors, and support systems are considered on a macroscopic level, and accidents that have occurred in the past are more easily researched. The PrHA is applicable for identifying potential accidents of relatively simple systems and procedures.

3.3.1.1 Hazard Identification

The hazard identification process involved identifying and inventorying hazardous materials and energy sources in terms of quantity, form, and location. Energy sources associated with the Waste Storage Facilities operations were also determined. The following conditions, which could impact the radioactive material inventory and potentially lead to a release, were investigated:

- Operational events (e.g., spills, fires, criticality, explosions)
- Natural phenomena (e.g., flooding, extreme winds, earthquakes, lightning)
- External events (e.g., accidents at nearby facilities, aircraft accidents)

A hazard was considered to be anything that could adversely affect workers, property, the public, or the environment. The hazard sources anticipated for the Waste Storage Facilities were determined through discussions with operations personnel, review of planned operations, design criteria, structural-design drawings, equipment specifications, and previous hazard analyses from similar RHWM operations.

To facilitate the hazard-identification process, the following six, specific categories of hazards were selected for investigation:

- Radiation sources
- Toxic, corrosive, or reactive materials
- Chemical energy (in the form of flammable, or explosive materials)
- Electrical energy
- Kinetic energy
- Potential energy

Common industrial hazards that make up a large portion of basic Occupational Safety and Health Administration (OSHA) regulatory compliance were evaluated only to the extent of determining their ability to initiate or contribute to accidents; otherwise, such hazards are adequately covered by 29 CFR 1910 implementation programs. Additionally, hazards associated with the safe operation of electrical equipment are governed by documents such as the National Electrical Safety Code and the National Electrical Code and, thus, were not addressed in this analysis.

A coarse screening of events was performed during the hazard-identification process. A physical-possibility screen was applied to identify those operational events, natural phenomena, and external events not physically possible as a function of site location or characteristics of the facility. All screened events were eliminated from further analysis. For example, events such as seiche and avalanches were eliminated on this basis.

Included as part of the hazard-identification process was a facility hazard classification and categorization conducted in accordance with Hildum (Hildum 2000) and DOE-STD-1027-92, Change Notice 1

(DOE 1997). This classification and categorization are based on a comparison of the facility inventory with threshold quantities of chemicals and radionuclides.

3.3.1.2 Hazard Evaluation

The methodology used to support the hazard analysis is a modification of the hazard analysis method described in the American Institute of Chemical Engineers, Guidelines for Hazard Evaluation Procedures, and is consistent with DOE-STD-3009-94, Change Notice 3. This methodology allows for consideration of potential effects on workers and the public, and is necessary to provide details for DSA accident analysis screening and updating.

The hazard analysis was conducted to ensure that all possible hazards were represented and considered. The focus of the hazard analysis is on potential accident conditions involving the hazards associated with the Waste Storage Facilities. Normal and abnormal conditions can also present hazards to the worker. However, these hazards are likely to involve minor exposures to contamination and other occupational hazards. These hazards are addressed in the facility description and the description of safety management programs (e.g., Radiation Protection Program) in Chapters 7 through 17 of this DSA.

In general, the hazard analysis consisted of a three-step process to:

- Systematically evaluate hazards, develop accident sequences, and identify administrative and engineered controls.
- Qualitatively assess frequency and consequence, for both unmitigated and mitigated accident sequences.
- Use the results to identify which controls should be preserved in the TSRs and the appropriate safety programs to effectively reduce the potential impact on the health and safety of the public and workers.

More specifically, based on the information acquired through the hazard-identification process, operations and systems in the Waste Storage Facilities were categorized into four types of scenarios: (1) Operations (waste storage, staging, handling, etc.); (2) Inadvertent Firearm Discharge; (3) External Events; (4) Natural Phenomenon Hazards.

The following information is provided for each scenario:

- **ID No**. Identifier to facilitate tracking of scenarios.
- **Hazard**. A description of the accident type.
- **Scenario**. Description of scenario, or family of scenarios, including identification of potential initiators.
- **Material at risk (MAR)**. Estimate of the inventory involved in the postulated scenario.
- **Initial Conditions**. Initial conditions are used to develop a physically meaningful scenario per DOE-STD-3009-94, Change Notice 3, Appendix A.

- **Unmitigated**. For a worker and the public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk to determine the scenario risk profile before controls are credited.
- **Control Type/Controls**. Appropriate safety features for eliminating, controlling, or mitigating the hazardous conditions. The controls identified fall within two groups:
  - Controls credited to reduce the frequency or consequence of the scenario.
  - Controls not specifically credited to reduce the frequency or consequence of the scenario, but that serve as defense-in-depth.
- **Mitigated**. For a worker and the public, a qualitative estimate of the scenario frequency, potential consequences, and associated risk to determine the scenario risk profile after controls are credited
- **Comments**. Statements provided to clarify scenario development, hazard-evaluation assumptions, or other issues

It is noted that the hazard analysis focused specifically on the worker (both facility and co-located) and the public. Site facility workers are typically protected by safety management programs. The impacts to the environment from the scenarios identified in the hazard analysis are considered less significant than the impacts to the public. As such, the controls identified in the hazard analysis are considered sufficient to address impacts to the environment.

The consequence and frequency ranking is combined to determine the risk ranking of each event. This process results in a relative risk ranking for each analyzed accident-family in the Waste Storage Facilities, based on its risk to the worker and the public. More information on the risk matrix development is presented subsequently.

Frequency Category Estimates

Each accident was assigned a frequency category based on the information in **Table 3-1**.

Table 3-1. Qualitative Frequency of Occurrence of Postulated Events

Frequency level	Acronym	Frequency	Qualitative description
Anticipated	A	$10^{-2} \le f \le 10^{-1}$/yr	Events that might occur several times during the lifetime of the facility (excluding normal operations)
Unlikely	U	$10^{-4} \le f < 10^{-2}$/yr	Events not anticipated during the lifetime of the facility
Extremely unlikely	EU	$10^{-6} \le f < 10^{-4}$/yr	Events that will probably not occur during the lifetime of the facility
Beyond extremely unlikely	BEU	$f < 10^{-6}$/yr	All other events

Frequency estimation considered facility or industry data, if well known and readily available, estimates, or analyst's judgment. For all instances, the best information available was used. Making estimates consists of the following steps:

1. Identification of a rough initial estimate of scenario frequency
2. Identification of the following:
   - Initiating-event frequency (per year)
   - Independent or dependent probabilities for other failures (e.g., hardware, human error, conditional probability of fire)
   - Number of repetitive operations over time
   - Period or percentage of time material is present
3. Combining all information to get final estimated scenario frequency.

Frequency of occurrence is not meant to be an absolute number but, rather, to express an expected frequency range. Frequencies are assigned to both unmitigated accidents (before controls are applied) and mitigated accidents (after controls are applied).

The estimate for unmitigated frequency of occurrence for each accident scenario is based on the assumption that no controls are in place to lower the frequency. Such estimates are based on an interpretation of "unmitigated" to mean that no special controls are implemented above and beyond standard industrial practices, waste packaging, and assumed initial conditions. The frequency of an accident scenario is a function of the frequency of the initiating event and the frequency of enabling events. Enabling events are those that must occur following the initiating event to result in the postulated accident. For example, for a transportation accident that initiates a fire in a storage area, if the initiating event is vehicle equipment failure (e.g., brakes), the enabling event could be a fuel leak that is ignited and starts a fire.

Frequency estimates for mitigated accident scenarios take into account controls that lower the frequency of occurrence of both the initiating event and enabling events. For the example scenario, inspection and maintenance programs can reduce the relative frequency of the postulated brake failure. The same program can also lower the frequency estimate for the enabling event, thus minimizing the overall scenario frequency.

Mitigated frequencies, along with the consequence, are used for selecting safety related (safety-class or safety-significant) and defense-in-depth controls. It is important to realize that the frequencies of occurrence used in the Process Hazard Analysis are not implied to be absolute numbers, but rather to express an expected frequency range of the postulated scenario.

Consequence Category Estimates

Qualitative consequence severity categories are assigned to each of the postulated accident scenarios. For radiological materials, the categories consider inventory, material form, and energy of release. For toxic materials the categories consider toxicity, inventory, and volatility. **Table 3-2** identifies the consequence severity levels, criteria used to establish them, and their impact. Public refers to the maximally exposed offsite individual (MOI) for releases of TRU waste that bounds releases of LLW. The nearest site boundary is located on Greenville Road, approximately 90 meters from the nearest storage area and 130 m from the nearest building in DWTF, and approximately 225 m from the nearest A625 boundary. The co-located worker is located not less than 100 meters from the point of release or the facility boundary, whichever is closer, or the point of highest dose is used for elevated releases or those involving plume lofting.

The site facility worker refers to the worker involved within the facility boundary, for whom safety programs, including training, typically provide assurances for operational safety. Unmitigated potential site facility worker consequences are qualitatively developed based on estimated co-located worker consequences using engineering judgment. The resulting site facility worker qualitative consequences are compared to the site facility worker criteria and interpretations to determine the severity level. The greater of the co-located worker or site facility worker consequence severity level results are presented in Appendix A.

Table 3-2. Severity Levels and Criteria

		Receptors		
		Offsite Public	**Worker**	**Site Facility Worker**
Consequence	High	Considerable off-site impacts on people or the environs. >25 rem[1] TEDE or >ERPG-2/TEEL-2	Considerable on-site impacts on people or the environs. >100 rem TEDE or >ERPG-3/TEEL-3	[2]Facility worker hazards are typically protected with Safety Management Programs. For Safety Significant designation, consequence levels such as prompt death, serious injury, or significant radiological and chemical exposure, should be considered.
	Moderate	Only minor off-site impact on people or the environs. ≥1 rem TEDE or >ERPG-1/TEEL-1	Considerable on-site impact on people or the environs. ≥25 rem TEDE or >ERPG-2/TEEL-2	
	Low	Negligible off-site impact on people or the environs. <1 rem or <ERPG-1/TEEL-1	Minor on-site impact on people or the environs. <25 rem or <ERPG-2/TEEL-2	

Notes:

[1] Offsite consequences >25 rem from operational accidents must be protected with Safety Class SSCs independent of frequency. Follow DOE-STD-3009 for manmade external and natural phenomenon events.

[2] Occupational Radiation Protection; incidental exposures during normal operations are governed by 10 CFR 835.

For the site facility worker, high consequence is interpreted as prompt worker fatality or an acute injury that is immediately life threatening or permanently disabling, or significant radiological or chemical exposures to workers. This would typically result from a radiological exposure to a large prompt dose (e.g., criticality level) or from a chemical exposure to sustained Immediately Dangerous to Life or Health (IDLH) levels (i.e., life-threatening or permanently disabling, as opposed to a brief peak exposure over ERPG-3 for a few minutes), where permanent effects may occur.

For the site facility worker, moderate consequence is interpreted as serious injury with hospitalization required, but no immediate loss of life and no permanent disabilities. This would typically result from a radiological exposure to a very energetic release to an occupied area (for alpha emitters); essentially a major accident destroying barriers as opposed to a confinement leak. A chemical exposure with moderate consequence would result in the worker being hospitalized with evident distress; with lingering physical effects in the hospital, though none permanent.

For the site facility worker, low consequence is interpreted as minor injuries, no loss of consciousness, with no hospitalization, to negligible impacts. This would generally result from a radiological exposure to a glovebox leak or small-scale confinement failure; and reflects the typical DOE complex occupational worker contamination or uptake. A chemical exposure with low consequence would result in short-term effects that dissipate quickly upon egress (e.g., eyes watering, cough) or no effects beyond irritation.

Unmitigated and mitigated public and worker consequences are estimated for each scenario in a semi-quantitative manner based on the material at risk, material form, and energy available. Mitigated consequences qualitatively estimate how effective the controls are in reducing the consequences from a release. The analysis identifies effective controls as candidates for consideration as Technical Safety Requirements (TSRs).

Risk Rankings

The frequency and consequence estimates, and the risk-ranking matrix in **Table 3-3**, are used to assign a risk rank to each accident scenario for workers and the public. Where the risk ranking is defined as: I – High, II – Moderate, III – Low, IV – Negligible.

Risk ranking I events must be protected with safety structures, systems, and components (SSC) and Technical Safety Requirements (TSR). For offsite public protection, Safety Class SSCs and TSRs are required for radiological events > 25 rem TEDE in accordance with Appendix A of DOE-STD-3009. Events which challenge but do not exceed 25 rem TEDE should be considered in selection of Safety SSCs and/or TSRs. Operational events resulting in high offsite radiological consequences must be moved forward into accident analysis for determination of safety classification, without consideration of frequency.

Risk ranking II events must be considered for protection with TSRs and safety SSCs. The consideration of control(s) shall be based on the effectiveness and feasibility of the considered controls along with the identified features and layers of defense in depth (DID). Operational events resulting in high offsite radiological consequences must be moved forward into accident analysis for determination of safety classification, without consideration of frequency.

Risk ranking III events are generally protected by the safety management programs (SMPs). These events may be considered for defense in depth SSCs in unique cases.

Risk ranking IV events do not require additional measures.

Table 3-3. Risk Group Ranking

		Frequency			
		Beyond Extremely Unlikely Below 10^{-6}/yr	**Extremely Unlikely 10^{-4} to 10^{-6}/yr**	**Unlikely 10^{-2} to 10^{-4}/yr**	**Anticipated 10^{-1} to 10^{-2}/yr**
Consequence	High	III	II	I	I
	Moderate	IV	III	II	I
	Low	IV	IV	III	III

Scenario Development

The PrHAs focused on key scenarios for each operation that denote the unique and representative potential accidents. This approach only addressed the highest unmitigated worker consequences and the highest unmitigated public consequences. The intent is to ensure that an adequate review of controls can be developed for mitigated risks. A graded approach for this Category 2 nuclear facility adequately evaluates risk commensurate with the segment's category and complexity without superfluous information in the PrHA.

Control Description

Preventive and mitigative controls that apply to the subject scenario are listed in the PrHA in Appendix A. The process involved identifying existing controls for the Waste Storage Facilities activities and proposing new controls as necessary. The total list of controls for a scenario gives an indication of the defense-in-depth that is provided. In the PrHA, controls that are initial conditions, and controls credited for reducing risk, are identified with single asterisks and double asterisks, respectively.

Once the PrHA tables were completed, the results were evaluated to determine if the controls identified were adequate.

3.3.2 Hazard Analysis Results

This section presents the results of the hazard identification, classification, and evaluation for the Waste Storage Facilities. Significant aspects of defense-in-depth and identification of any safety SSCs and other items potentially requiring TSR coverage are summarized.

3.3.2.1 Hazard Identification

This subsection presents the results of the hazard-identification activity. Attributes of the hazards identified here are the basis for subsequent hazard evaluation. The principal hazards in the Waste Storage Facilities are in the form of radioactive material.

3.3.2.1.1 Identification of Hazards

The hazards associated with the Waste Storage Facilities were identified through the use of a checklist and discussions with program personnel. Such hazards do not necessarily have a quantity or type associated with them, and they can exist in all locations throughout the segment. The hazards identified in **Table 3-4** were considered while developing the PrHA.

Table 3-4. Waste Storage Facilities Hazard Source List

Source Category	Hazards List
Motion/ Mechanical	Vehicles, mass in motion, belts, gears, chains, sharp edges, pinch points, push carts, forklifts
Gravity-mass	Falling, falling objects, roll-up doors, lifting, hoists, tripping, slipping, earthquakes
Static	Container rupture, overpressurization, negative pressure effects
Natural Phenomena	Earthquake, wind, flood, lightning
Cold	Ice, snow, wind, rain, cold surfaces, compressed gases
Heat	Electrical equipment, hot surfaces, electricity, friction, solar, fire
Flammable materials and fires	Presence of flammable/combustible material—solid, liquid, gas Presence of ignition source—engines, sparks
Pressure	Confined/compressed gases, pressurized liquids, objects propelled by pressure, noise
Electrical	Static electricity, power supplies, power cables, transformers, wiring, batteries, exposed conductors, other high-voltage sources, lightning
Radiant	Intense light (electric arc welding), RF fields, infrared radiation (welding), solar, ionizing radiation, electromagnetic radiation, neutrons
Chemical (present, combustion product, or reaction product)	Flammable/combustible materials (e.g., hydrogen from radiolytic decomposition of materials), asphyxiants, carcinogenic materials, toxic materials, reproductive hazards
Chemical reaction (non-fire)	Corrosion, rust, and related hazards (e.g., heat and pressure)
Criticality	Although the average loading of fissionable materials in individual containers is below levels that would cause any criticality concern, the total fissionable material inventory in this facility exceeds the minimum critical mass

3.3.2.1.2 Identification of Radionuclide Inventories

Waste Storage Facilities will serve as a storage repository for a variety of radioactive waste such as liquid and solid TRU waste, LLW, mixed waste, and combined waste. Waste generators are responsible for collecting, packaging, identifying, and labeling the wastes prior to transfer to the Waste Storage Facilities.

Typical TRU waste consists of contaminated wiping tissues, paper, plastic, chemistry glassware, ceramics, and metal. The storage of TRU with water-reactive materials, pyrophorics, and other reactives is not authorized. All TRU waste is packaged in approved TRU waste containers as described in Section 4.4.1.3.

Table 3-5 summarizes the principal radionuclides and provides a historic quantity for each radionuclide for a typical waste storage facility that represents the facility containing the greatest quantity of TRU waste. This information is not a limit or a restriction on radionuclides, but is representative historical data provided only for information purposes. The inventory of radionuclides is entered into a database management system that is maintained by RHWM for recordkeeping and retrieval for each facility.

Table 3-5. Representative Radionuclides for a Typical Waste Storage Facility

Radionuclide	Historic Quantity (g)
Am-241	38
Am-243	0.030
Cf-249	1.6×10^{-4}
Cm-243	6.9×10^{-9}
Cm-244	0.010
Co-60	4.9×10^{-10}
Cs-137	7.0×10^{-9}
Eu-154	5.4×10^{-6}
H-3	0.16
Np-237	2.3
Pu-238	3.9
Pu-239	3,200
Pu-240	260
Pu-241	9.3
Pu-242	3.1
U-233	0.36
U-234	4.6×10^{-4}
U-235	220

TRU waste is defined as waste contaminated with alpha-emitting transuranic radionuclides (with half-lives greater than 20 years) in excess of 100×10^{-9} Ci/g or 100 nCi/g. Therefore, LLW contains a maximum of 100 nCi/g of TRU isotopes, for radionuclides with half-lives greater than 20 years. Because of the allowable concentrations, the maximum radioactive inventory for these isotopes in a drum containing LLW is very small, as calculated below:

$$MAR = 100\times10^{-9}\ {}^{Ci}\!/_{g} \times 4.54\times10^{2}\ {}^{g}\!/_{lb} = 4.5\times10^{-5}\ Ci \ \ per\ 1\ lb\ of\ \ LLW$$

A review of LLNL approved TRU waste drums identified that they contain a net mass of less than 1,000 pounds. This results in 0.05 Ci per container of TRU isotopes, for radionuclides with half-lives greater than 20 years, when loaded to 1,000 pounds. The PE-Ci is calculated using Dose Conversion Factors (DCFs) that account for all radiation, not just alpha particles. Although there are a number of transuranic isotopes with half-lives less than 20 years, such as Cm-244, these isotopes typically do not contribute significantly to the PE-Ci for LLW in the Waste Storage Facilities. All radioactive waste accepted by RHWM must be contact-handled waste so that the surface dose rate of a radioactive waste container may not exceed 200 mrem/hr. Based on the LLW inventory in May 2004, the total combined PE-Ci for the over 3200 LLW containers in the Waste Storage Facilities was just over 1 PE-Ci. The maximum PE-Ci in any single LLW container was 0.20 PE-Ci, and only 15 of the over 3200 containers had greater than 0.01 PE-Ci. Hence, a postulated accident involving drums containing LLW is bounded by that involving TRU waste containers. Consistent with the graded approach, a potential accident involving LLW other than tritium is not evaluated in Section 3.4.2.

3.3.2.1.3 Identification of Chemical Inventories

Although RHWM handles a large quantity of hazardous waste, the primary waste streams would be described as industrial hazardous waste such as dilute aqueous solutions, paint, oil, solvents, dilute corrosives, and fluorescent tubes. Before waste can be accepted, it goes through a series of reviews. One of these reviews is to verify if the waste meets the requirements of the Hazardous Materials Protection Program.

3.3.2.2 Hazard Categorization

This subsection presents the segmentation and classification of the Waste Storage Facilities from the remainder of the DWTF facilities, and the results of the Waste Storage Facilities final hazard classification activity outlined in DOE-STD-1027-92, Change Notice 1.

3.3.2.2.1 Segmentation

The DWTF Complex, shown in Figure 2-2, contains two nuclear facilities: the DWTF Storage Area and the B695 Segment of DWTF. The DWTF Storage Area is addressed in this DSA; the B695 Segment is addressed in a separate DSA (LLNL 2004a). Segmentation of the DWTF Storage Area from the B695 Segment was performed by considering future operations in the DWTF as well as existing operating facilities. The B695 Segment consists of B695, B696S, and the adjacent yard area, and is used primarily for waste treatment.

Fire, earthquake, and aircraft crash are potentially the worst common-cause events identified in this DSA that could lead to uncontrolled radioactive release from several contiguous nuclear facilities. All buildings in the DWTF Complex are at least 48 ft apart (B695 and B696 have a truck bay between them), and the area between them is covered with asphalt. This separation, in conjunction with each building's non-combustible, PC-2 construction, amply serves as a passive barrier in the form of a firebreak. In addition, RHWM will maintain a 20-ft firebreak marked appropriately between the DWTF Storage Area and the B695 Segment of DWTF as part of the fire protection program.

It is shown in the segmentation justification provided in Appendix E of the *Documented Safety Analysis for the B695 Segment of the Decontamination and Waste Treatment Facility* (LLNL 2004a) that the B695 Segment of DWTF is sufficiently separated physically from the DWTF Storage Area and that passive barriers exist if the separation distance is not adequate as in the case of the partition separating B696R and B696S. As discussed in Appendix E, the combination of the B696S/B696R partition and the TSR combustible loading limits precludes a fire from propagating from one side of the partition to the other. In addition, independence of pertinent systems precludes the potential for concurrent release of materials from common cause or common mode failure in the DWTF Storage Area and the B695 Segment of DWTF from postulated aircraft crash, fire or earthquake. Therefore, segmentation of the DWTF Storage Area from the remainder of the DWTF complex is in accordance with the requirements of DOE-STD-1027-92, Change Notice 1 (DOE 1997).

3.3.2.2.2 Radiological Hazard Categorization

The Waste Storage Facilities contain TRU waste in excess of 56 PE-Ci, the threshold quantity for HC-2 nuclear facilities in Table A-1 of DOE-STD-1027-92, Change Notice 1. Therefore, the Waste Storage Facilities are categorized as Hazard Category 2 nuclear facilities.

3.3.2.2.3 Chemical Hazard Classification

The Waste Storage Facilities are used to handle and store hazardous waste, TRU waste, LLW, mixed waste, combined waste, nonhazardous industrial waste, and conditionally accepted waste generated at LLNL. Although RHWM handles a large quantity of hazardous waste, the primary waste streams would be described as industrial hazardous waste such as dilute aqueous solutions, paint, oil, solvents, dilute corrosives, and fluorescent tubes.

Analyses of the chemical hazards of the Waste Storage Facilities were performed using LLNL *ES&H Manual* Document 3.1, “Safety Analysis Program,” revision April 2001 (LLNL 2001) and Hildum (2000) that showed these facilities met the criteria for Low Hazard facilities. The path forward regarding the March 2004 Document 3.1, “Nonnuclear Safety Basis Program,” (LLNL 2004b) for the Waste Storage Facilities will be developed by the next annual update.

3.3.2.3 Hazard Evaluation

This section provides the analysis of the Waste Storage Facilities operations. The analysis uses the graded-approach, which prescribes that an analysis technique be no more sophisticated or detailed than necessary to present a comprehensive examination of the hazards associated with a facility (DOE 2006).

The generic hazards from energy sources, materials, and natural phenomena associated with the Waste Storage Facilities were identified in **Table 3-4**. These generic hazards were developed into hazard scenarios as documented in the PrHA in Appendix A using the methodology in Section 3.3.1.2.

The focus of the hazard analysis is on potential accident conditions involving the generic hazards associated with the Waste Storage Facilities. Normal and abnormal conditions can also present hazards to a worker. However, such hazards are likely to involve minor exposures and other occupational injuries. For the site facility worker, such hazards are typically addressed by the safety management programs (e.g., Radiation Protection Program) in Chapters 7 through 17 of this DSA. Initiating events involving the hazards discussed above are presented in the following sections.

WASTE-STORAGE/STAGING/HANDLING OPERATIONS EVALUATION

Scenarios involving waste storage, staging, handling, or operations were identified and evaluated in the PrHA in this DSA for the DWTF and A625 Waste Storage Facilities. These include:

1. scenarios involving forklifts or vehicles (e.g., trucks) that impact drums resulting in either a spill or fire,

2. loading or unloading scenarios resulting in a spill,

3. cylinder failure scenarios resulting in a spill,

4. crane operations scenarios resulting in a spill,

5. electrical failure or welding accident scenarios leading to a fire,

6. container deflagration scenarios,

7. criticality scenarios,

8. tritium scenarios resulting in either a spill or fire, and

9. chemical release scenarios resulting in either a spill or fire that does not have a potential to release radioactive material.

Forklift/Vehicle Scenarios Impacting TRU Waste (DWTF: WH-1, WH-1A, WH-4, WH-8, WH-8A, WH-9, A625: WH-1, WH-1A, WH-4, WH-10, WH-10A, WH-11)

Scenarios involving forklift or vehicle accidents could result in the release of radioactive material due to a spill and/or fire. Credible initiators for such scenarios include personnel error in misjudging speed, container mishandling, and vehicle fires near stored containers. Although misjudging speed is considered to be an initiator for the accident scenarios, the hazard analysis assumes that speed is not a factor with respect to the consequences of the accident. For conservatism, the analysis assumes that the vehicle collides with staged containers resulting in a complete loss of waste to the facility floor or yard area.

The unmitigated frequency of a spill following a forklift/vehicle accident is estimated in accordance with the general guidelines described in Section 3.3.1.2. Container spills caused by vehicle accidents are estimated to be "anticipated" for a minor spill and "unlikely" for a significant spill. Crediting the traffic control program (e.g., vehicles are required to stop at yard gate prior to entry and posted speed limits in the yard) would lower the mitigated frequency by one frequency bin.

For scenarios involving spill and fire following a forklift/vehicle accident the unmitigated frequencies are lowered one bin (e.g., "unlikely" to "extremely unlikely") to account for the conditional probability of a fuel spill and ignition in a vehicle accident.

Co-located worker consequences were estimated as "low" for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. Movement of TRU waste requires a minimum of two personnel, which further supports a reasonable detection and emergency response to any event. In some scenarios, the public consequences were estimated as "moderate," while worker consequences were "low." This estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity.

The potential unmitigated consequences are estimated as "low" for the worker and the public for spills within A625 and for spills from the DWTF storage facilities involving one drum and minor spills, and are estimated as "low" for the worker and "moderate" for the public for significant spills from the DWTF storage facilities involving pallets of drums.

The potential unmitigated consequences are estimated as "low" for the worker and the public for fires within A625 and DWTF storage facilities involving one drum, and are estimated as "low" for the worker and "moderate" for the public for fires with A625 and the DWTF storage facilities involving pallets of drums.

After controls are credited, all scenarios involving forklift/vehicle accidents represent a "low" or "negligible" risk to the public and worker.

Forklifts and trucks powered by hydrocarbon fuels are potential sources of flammable materials. Generally, diesel and gasoline fuel tanks on forklifts are located on the side and are shielded with a 1/4-inch steel plate. Propane tanks are typically mounted at the rear at the elevated position of the operators. Due to these types of fuel tank configurations, the fuel tanks are not easily accessible to result in a breach of their integrity in a collision with other vehicles or internal building components or systems. Furthermore, the maximum speed attainable by a forklift is limited such that an impact is not anticipated to lead to a catastrophic fuel tank failure.

Trucks used by RHWM to transport waste are designed in accordance to national standards. For light trucks, the gross weight of which is less than 10,000 lb, Federal Motor Vehicle Safety Standards and Regulations (FMVSS) 301 issued by the National Highway Traffic Safety Administration (NHTSA) has criteria for allowable fuel spillage in the event of a 30-mph front end impact onto a fixed barrier. A front-end impact is considered the primary hazard of concern for trucks impacting staged waste. The amount spilled is based on the duration of time after impact but the criterion is in the range of just a few ounces of fuel spilled. Additionally, fixed barriers would cause the force of the impact to be absorbed mostly by the vehicle causing more damage, whereas a pallet of drums would be toppled or would move and little impact force would be transferred to the vehicle.

For heavy trucks, which exceed 10,000 lb gross weight, the governing Department of Transportation (DOT) regulation is 49 CFR 393.67, Liquid Fuel Tanks. Section (e)(1) in 49 CFR 393.67 specifies that the acceptable leakage is no more than one ounce of water per minute for a 30-foot drop test involving a fuel tank filled with water dropped on one corner.

The consumption rate to sustain a large gasoline pool fire is 0.5 gpm (64 ounces per minute) per 1 MW (WM/FS-WSF-0404). The postulated 9-MW fire requires approximately 4.5 gpm (576 ounces per minute) to sustain the fire. This is far in excess of ounces of fuel leakage allowed from a 30-mph impact.

Loading or Unloading Scenarios (DWTF: WH-2, WH-2A, WH-3, A625: WH-2, WH-2A, WH-3)

Scenarios during radioactive material container loading or unloading operations could result in the release of radioactive material due to a container breach and subsequent spill. Credible initiators for such scenarios include personnel error in positioning, container mishandling, or mechanical problems with loading equipment.

The unmitigated frequency of a spill due to a loading or unloading accident is estimated as “anticipated” for minor and one drum spills, and “unlikely” for significant spills. Crediting the use of certified forklift operators (licensed operators whose training includes formal instruction, practical application, and performance evaluation) would lower the mitigated frequency by one frequency bin (e.g., “unlikely” to “extremely unlikely”).

Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. Loading or unloading of TRU waste requires a minimum of two personnel, which further supports a reasonable detection and emergency response to any event. In some scenarios, the public consequences were estimated as “moderate,” while worker consequences were “low.” This estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity.

The potential unmitigated consequences are estimated as “low” for the worker and the public for spills within A625. The potential unmitigated consequences are estimated as “moderate” for the public and “low” for the worker when a pallet results in a significant spill, and “low” for the public and worker for a minor pallet spill and drum spill within DWTF storage facilities.

After controls are credited, all scenarios involving loading or unloading accidents represent a “low” or “negligible” risk to the public and worker. Subsequent analysis in Section 3.4.2.2 identified that the initial potential consequences were considerably overestimated and that the candidate credited controls are not necessary for this scenario due to the low potential doses to the worker and public.

Cylinder Failure Scenarios (DWTF: WH-5, A625: WH-5)

Scenarios involving pressurized gas cylinder failure could result in the release of hazardous material or generate a projectile that could impact and breach an approved TRU waste container resulting in a radioactive material spill. Credible initiators for such scenarios include a structural failure of the cylinder or container mishandling that could result in cylinder failure.

The unmitigated frequency for a structural failure of the cylinder or a container mishandling event resulting in cylinder failure that could release of hazardous material or generate a projectile that could impact and breach an approved TRU waste container releasing radioactive material is estimated as “extremely unlikely.”

Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the projectile would not incapacitate a worker by direct impact within the normally unoccupied area and the workers will observe the accident and leave the scene in a timely manner.

The potential unmitigated consequences are estimated as “low” for the worker and the public for all cylinder failure scenarios.

The scenarios involving pressurized gas cylinder failure accidents represent a “negligible” risk to the public and worker.

Crane Operation Scenarios (DWTF: WH-17, WH-18, A625: WH-7, WH-8)

Scenarios involving crane operations could result in the release of radioactive material from impacting and breaching an approved TRU waste container with the load, impacting and breaching approved TRU waste containers with the crane boom, or dropping approved TRU waste containers during lifting. B625 has a 3-ton overhead bridge crane. Mobile cranes can be brought into DWTF or A625 to perform activities, such as maintenance or movement of transportainers. Credible initiators for such scenarios include operator error or failure of the hoisting and rigging.

The unmitigated frequency for a crane operation accident releasing radioactive material from a single TRU waste container load is estimated as “anticipated.” The unmitigated frequency for a crane operation accident releasing radioactive material from multiple TRU waste containers is estimated as “unlikely.” Crediting the use of certified crane operators (licensed and qualified per LLNL requirements) lowers the mitigated frequency by one frequency bin to “extremely unlikely.”

Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be the result of physical trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. Crane operations require multiple personnel, which further supports a reasonable detection and emergency response to any event.

The potential unmitigated consequences from a crane operation accident are estimated as “low” for the worker and the public for all crane operation accident scenarios for A625 and all crane operation accident scenarios involving single TRU waste containers for the DWTF storage area. The potential unmitigated consequences from a crane operation accident are estimated as “low” for the worker and “moderate” for the public for crane operation accident scenarios involving multiple TRU waste containers for the DWTF storage area.

Scenarios involving crane operation accidents represent a "low" or "negligible" risk to the public and worker.

Electrical Failure or Welding Accident Fire Scenarios (DWTF: WH-10, WH-11, A625: WH-12, WH-13)

Initiation of a fire involving plastic pallets used for non-TRU waste storage, electrical cables, or equipment can potentially occur only from an electrical short or exposure fire and combustion of damaged or worn insulation. A fire will be sustained only if a significant decomposition of insulating materials has occurred, i.e., the 1% thermal decomposition is not sufficient for a large fire. The 1% thermal decomposition temperature of polyvinyl chloride, a typical insulation material, is 457°K (363°F) (SFPE 1995). Other energy sources in the vicinity of the electrical cables and equipment necessary to maintain high temperatures and cause significant thermal degradation are limited in the Waste Storage Facilities.

In addition, the limiting oxygen index (LOI)—a measure of the tendency for a material, once ignited, to continue burning after the ignition source is removed—is typically very high for the insulating materials. For polyvinyl chloride, the LOI is 47 compared to 20 for cotton (SFPE 1995). A high LOI indicates that wire insulation requires a relatively large exposure fire to become self-propagating; rather, it will stop burning once the ignition source is removed. Quantities of combustibles in proximity to the electrical cables and equipment are not sufficient for a large exposure fire in non-flammable storage areas. Hence, initiation and propagation of an electrical fire is not likely in the Waste Storage Facilities.

These scenarios require significant combustible material. Combustible loading in the Waste Storage Facilities TRU waste storage areas is consistent with Table 7-5A in the *Fire Protection Handbook*, 18th edition (NFPA 1997), that limits allowable combustibles in accordance with the fire-resistive rating of the partitions of a compartment in a building. The combustible loading limit is established to preclude the potential for fire propagation. The allowable combustible loading is 5 psf per each half-hour fire-resistive rating of a partition or a wall that separates the compartments. For compartments separated by a one-hour fire-rated partition, such as B696R Rooms 1010 and 1011, the combustible loading allowed by Table 7-5A in *Fire Protection Handbook*, 18th edition, is 10 psf. For conservatism in a TRU waste storage facility, a lower combustible loading limit of 7 psf is conservatively established, which is consistent with the definition of light fire loading discussed in NPFA 80A.

Occasional welding, using either electrical arc or hot flame (oxyacetylene or MAAP gas), may be required to maintain important building systems. In addition, equipment such as gas torches and plasma cutters may be used for activities such as size reduction. Before hot work could be performed, a Hot Work Permit must be issued by Emergency Management to ensure personnel who perform welding, soldering, and other hot-work operations with a high fire potential are aware of and protected from hazards.

Co-located worker consequences were estimated as "low" for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be related to elevated temperature and smoke rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. An observer is required during operations involving hot work, which further supports a reasonable detection and emergency response to any event. In some scenarios, the public consequences were estimated as “moderate,” while worker consequences were “low.” This estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity.

For conservatism, a fire initiated by an electrical failure or other ignition source in conjunction with a flammable liquid spill is considered an “extremely unlikely” event and a welding accident (including flammable gases) is considered an “unlikely” event. For these scenarios, the unmitigated consequence to the public is considered “moderate” and the unmitigated consequence to the worker is considered “low.” An element of the combustible control program that requires all waste in TRU waste storage areas to be in metal containers and on metal pallets is credited for WH-11 to reduce the frequency of such events. This control minimizes available combustibles in the room, thereby reducing the likelihood of an ignition source finding combustibles to ignite resulting in a release of material. After controls are credited, the electrical failure/welding accident fires are a “low” risk to the public and “negligible” risk to the worker.

Container Deflagration Scenarios (DWTF: WH-14, WH-15, A625: WH-16, WH-17)

Two types of container deflagration scenarios are evaluated, vented and unvented. For unvented containers, the unmitigated frequency for a deflagration scenario is considered “unlikely.” Container bulging is a sign that pressure buildup is occurring. A periodic inspection of containers to detect bulging and to verify the container integrity would lower the mitigated frequency by one frequency bin. Crediting the container maintenance program (a portion of the In-service Inspection & Test Program), a mitigated deflagration in an unvented container is considered “extremely unlikely.” For vented containers, the unmitigated frequency is considered “extremely unlikely” and does not require a credited control. Incorporating the container maintenance program, the mitigated frequency would be considered “beyond extremely unlikely.”

Co-located worker consequences were estimated as “low” for these scenarios. Site facility worker consequences are not consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location; they are qualitatively judged to have the potential for higher consequences. The resulting radioactive uptake may result in serious injury, but it is not expected to be life threatening or permanently disabling. The primary concern for worker injuries would be physical trauma due to the pressurized release of the lid impacting the worker, which represents a standard industrial hazard. Thus, the site facility worker consequences were estimated as “moderate.” For protection for the worker in the event of drum lid loss resulting from a deflagration, an additional control is included requiring use of drum lid restraining devices during transport of pressurized unvented TRU waste drums unless the drums are overpacked.

For the unmitigated case, the consequences to the worker and the public are considered “moderate” and “low,” respectively, for A625 and the DWTF storage facilities.

After controls are credited, the mitigated container deflagration accidents are considered a "negligible" risk to the public and a "low" risk to the worker for A625 and the DWTF storage facilities.

Additionally, a fire following a hydrogen deflagration is not postulated due to thermal limitations. Based on HC/AB-B696-0202 and SFPE (1995), a drum containing 1 lb of contaminated cellulosic materials, the temperature increase is less than 22°C, which is not sufficient to reach the exothermic pyrolytic decomposition temperature of 280°C. Even at the stoichiometric concentration, the potential combustion energy from a deflagration, equal to 150 kJ, is not sufficient to bring contaminated cellulosic materials to the exothermic pyrolytic decomposition temperature of 280°C or a small quantity of polyethylene to 1% thermal degradation temperature of 275°C.

Criticality Scenarios (DWTF: WH-16, A625: WH-18)

Unmitigated criticality events are considered to be "extremely unlikely." With the criticality safety program in place, which limits the quantity of fissile materials, moderators, and reflectors, criticality events are considered "beyond extremely unlikely." The criticality safety program is discussed in Chapter 6, and includes a fissile material inventory limit per container of 200 Pu-239 fissile gram equivalents (FGE).

Co-located worker consequences were estimated as "low" for these scenarios. Site facility worker consequences are not consistent with the co-located worker consequences. Workers closer to the point of release could receive a prompt radiation dose that would have significantly higher consequences than exposure to the fission products generated. This could result in consequences that are life threatening or result in permanently disabling injuries for the site facility worker. Thus, the site facility worker has the potential for "high" consequences due to a criticality event.

Potential mitigated consequences to the worker are considered "high" and the mitigated consequences to the public are considered "low" for DWTF storage facilities and "low" for A625 storage facilities. The resulting risk to the public is considered "negligible" and the worker is considered "low" for the mitigated case.

Tritium Contaminated Waste Scenarios (DWTF: WH-6, WH-12, A625: WH-9, WH-14)

Scenarios involving tritium contaminated waste could result in the release of molecular tritium (HT or T2) or tritiated water (oxidized or HTO/T2O) due to a spill or fire. Credible initiators for such scenarios include operator errors.

Co-located worker consequences were estimated as "low" for these scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, but they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure, and the form of the tritium waste and nature of tritium does not readily support a locally sustained release.

The unmitigated frequency for a waste contaminated tritium accident releasing significant amounts of molecular or oxidized tritium is estimated as "unlikely" for a spill or a fire.

The potential unmitigated consequences from a tritium accident are estimated as "low" for the public and "low" for the worker for tritium accident scenarios.

Scenarios involving tritium accidents represent a "low" risk to the public and a "low" risk for the worker.

Chemical Containing Waste Scenarios (DWTF: WH-7, WH-7A, WH-7B, WH-13, WH-13A, WH-13B, A625: WH-6, WH-6A, WH-6B, WH-15, WH-15A, WH-15B)

Scenarios involving chemical containing waste accidents could result in the release of a hazardous chemical due to a spill or fire. Credible initiators for such scenarios include operator errors and system failures.

The probability of the hazardous chemical release events is dependent on the quantity of hazardous chemicals released during an accident. Typical releases are small spills that do not release the entire contents of a container. The unmitigated frequency for a chemical containing waste accident releasing small amounts of a hazardous chemical is estimated as "anticipated." Releases of the entire contents of a container will have a lower frequency. Chemical inventory reviews demonstrate that more than 99% of containers released could result in consequences ≤TEEL 1. The unmitigated frequency for a chemical containing waste accident releasing an entire container of a hazardous chemical significantly less than the SCIL is estimated as "unlikely." Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL 1 and ≤TEEL 2. The unmitigated frequency for a chemical containing waste accident releasing an entire container of a hazardous chemical approaching or at the SCIL is estimated as "extremely unlikely." The unmitigated frequency of a chemical containing waste accident with a subsequent fire is estimated to be the same as the spill scenarios for the different quantities.

Co-located worker consequences were estimated as "low" for scenarios involving small releases and releases of greater quantities of waste but in amounts significantly less than the SCIL. Site facility worker consequences are consistent with the co-located worker consequences. While workers closer to the point of release could receive a higher exposure as compared to the exposures evaluated at the onsite receptor location, this is qualitatively judged to have a minimal impact on potential consequences. Worker injuries would primarily be minor related to the type, form, and quantity of hazardous material involved. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner.

Co-located worker consequences were estimated as "moderate" for scenarios involving releases of greater quantities of waste in amounts approaching or at the SCIL. Site facility worker consequences are consistent with the co-located worker consequences. Although workers closer to the point of release could receive a higher exposure as compared to the exposures evaluated at the onsite receptor location, they are qualitatively judged to have a similar potential for injury because a worker would have to remain in the vicinity and receive a sustained exposure rather than a brief peak exposure in order to result in significant consequences. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. Waste operations require a minimum of two personnel, which further supports a reasonable detection and emergency response to the event. Worker injuries could result in serious injury, but it is not anticipated that site facility workers would receive a sustained exposure that would be immediately dangerous to life or health.

The potential unmitigated consequences from chemical containing waste accidents are estimated as “low” for the public and the worker for small releases and releases of greater quantities of waste but in amounts significantly less than the SCIL, and as “moderate” for the public and the worker for releases of greater quantities of waste in amounts approaching or at the SCIL. Scenarios involving chemical containing waste represent a “low” risk to the public and the worker.

The Hazardous Material Protection Program ensures the Waste Storage Facilities are Low Hazard facilities and provides protection of the public, the co-located worker, and the site facility worker from chemical releases. A portion of the Hazardous Material Protection Program that is unique to the Waste Storage Facilities is the SCIL Program, which is used to control the inventory of hazardous chemicals in waste. This program limits the quantity of a chemical that can be stored in any one container based on a series of criteria such as the toxicity and vapor pressure of the material. The SCIL limits the consequences to the public and the co-located worker. The Hazardous Material Protection Program and the SCIL Program are further discussed in Chapter 8.

Waste-Storage/Staging/Handling Operations Preventive and Mitigative Features

Candidate preventive and mitigative features for the operational events include the following:

- A limit of 50 PE-Ci of radioactive material per container, with the exception of tritium which is limited to 2,000 Ci per container
- TRU waste staged outside the building will be limited to arrays with a maximum inventory of 200 PE-Ci per array and limited to 36 hours. Any one array of staged drums shall be separated from other arrays by no less than 10 feet.
- TRU waste will be stored in approved TRU waste containers
- Fissile material inventory per container is limited to 200 Pu-239 FGE
- Traffic controls are established in the Waste Storage Facilities yards
- Hazardous material protection program, including the SCIL program to control the inventory of hazardous chemicals in waste
- Container maintenance program (a portion of the In-service Inspection & Test Program)
- Combustible loading controls to minimize and control the use of combustible materials, including limiting waste containers to metal containers on metal pallets in TRU waste storage areas
- Criticality safety program to ensure that the potential for an inadvertent criticality event is precluded
- An emergency preparedness program for the Waste Storage Facilities to train employees on appropriate emergency response actions.
- A training program, including certification and qualification of forklift and crane operators
- Drum lid restraining devices are used during transport of pressurized unvented TRU waste drums unless the drums are overpacked.

INADVERTENT FIREARM DISCHARGE HAZARDS EVALUATION

Inadvertent Firearm Discharge (DWTF: DFA-1 to DFA-11, A625: AFA-1 to AFA-10)

For DWTF DFA-1 to DFA-9 and A625 AFA-1 to AFA-8, the PrHA accident frequencies that result from an inadvertent firearms discharge of security personnel that cause an uncontrolled release of hazardous material range from "unlikely" to "beyond extremely unlikely." These frequencies are one frequency bin lower than comparable events initiated by a small breach in a container or system because armed security personnel are not assigned to the DWTF or A625 and rarely visit the facilities. For conservatism, the consequences for all uncontrolled releases of hazardous material resulting from the inadvertent discharge of a firearm are the same as those for other events initiated by a small breach in a container or system. Security controls identified in the PrHA table, although not credited with reduction in risk, include preventive engineering controls such as bolt locks, centerfire cartridges, holsters, loading stations, MILES equipment, safety on firearm, and trigger guards, and preventive administrative controls such as procedures and training.

The only routine operation where security personnel are present within the DWTF is during the inspection of a TRUPACT-II shipment by California Highway Patrol (CHP) personnel immediately prior to the shipment leaving the facility. This inspection takes approximately 2 hours. Additionally, the CHP are normally armed and escorted by armed LLNL security personnel.

Inadvertent weapon discharge for other events (DFA-10, -11 and AFA-9, -10) has the potential for "high" consequences to the worker with an unmitigated frequency of "beyond extremely unlikely" as discussed in LLNL 2006a.

EXTERNAL EVENTS HAZARDS EVALUATION

Five external event scenarios were deemed appropriate for analysis in this report for the DWTF Waste Storage Facilities. These scenarios include:

1. an aircraft crash resulting in a spill;
2. an aircraft crash resulting in a spill and fire;
3. an external fire that impacts the segment;
4. an accident at a nearby facility that impacts the segment; and
5. a natural gas line breach.

Six external event scenarios occurring during waste-storage, staging, handling, or operations were identified for analysis in this DSA for the A625 Waste Storage Facilities. These scenarios include:

1. an aircraft crash resulting in a spill;
2. an aircraft crash resulting in a spill and fire;
3. an external fire that impacts the segment;
4. an accident at a nearby facility that impacts the segment;

5. a breached natural gas line; and
6. an overhead power line break resulting in a fire.

Other external events (e.g., nuclear test activity, strong radio transmissions, and structural interaction) were removed in the screening because of site characteristics. Still others were eliminated in the screening because they were not considered credible for affecting the waste containers in the facility.

Aircraft Crash (DWTF & A625: EE-1, EE-2)

The unmitigated frequencies for aircraft crashes into Waste Storage Facilities structures or staging areas were conservatively estimated in consultation with DOE. For DWTF, an aircraft crash into B696R yielding only a spill was estimated to be marginally "extremely unlikely." An aircraft crash with a significant post-crash fire was estimated to be "beyond extremely unlikely." An aircraft crash into B693 with a significant post-crash fire was historically estimated to be "extremely unlikely," but that is no longer a candidate event as authorization for TRU waste in B693 has been withdrawn in this DSA. For A625, a bounding aircraft crash into B625 was estimated to be "extremely unlikely."

The potential unmitigated consequences of an aircraft crash into any Waste Storage Facilities facility resulting in a spill only are estimated as "low" for the public and the worker. The potential unmitigated consequences are estimated as "moderate" for the public and the worker for an aircraft crash into Waste Storage Facilities facility resulting in a fire. Facility worker consequences were not estimated in the immediate proximity of the crash as the event itself and the subsequent fire would yield worker fatalities independent of any radiological release. Workers at some reasonable stand off distance would not experience "high" consequences from a radiological release.

The unmitigated aircraft crash scenarios resulting in a spill represent a "negligible" risk to the public and worker in A625 and DWTF waste storage facilities. The unmitigated aircraft crash scenarios resulting in a fire represent a "low" risk to the public and the worker in A625 and a "negligible" risk at DWTF waste storage facilities.

Co-located worker consequences were estimated as "low" for aircraft spill scenarios. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be related to impact trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. The nature of an aircraft crash provides indication of the event, which further supports a reasonable detection and emergency response to any event.

Co-located worker consequences were estimated as "moderate" for aircraft fire scenarios. Site facility worker consequences are not consistent with the co-located worker consequences. Worker injuries would primarily be related to heat, smoke, and physical trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location; however, this is qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure.

The physical impacts and subsequent fire from the crash itself could result in non-radiological consequences that are life threatening or cause permanently disabling injuries for the site facility worker. However, this potential derives from an externally imposed initiator that is immune to any intervention by either facility management or DOE. It is thus outside the envelope of consequence ranking in an analysis performed to define facility controls.

External Fire (DWTF & A625: EE-3)

The frequency of an external fire occurring that could impact the DWTF or A625 Waste Storage Facilities is considered "extremely unlikely." The unmitigated consequences are estimated as "moderate" for the public and "low" for the co-located workers. Site facility worker consequences are consistent with the co-located worker consequences. The "moderate" public consequence estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location; however, this is qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure and a worker would have to remain in the plume for an extended period of time (hours) in order to receive a significant exposure. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. The nature of an external fire provides indication of the event, which further supports a reasonable detection and emergency response to any event. The external fire scenario represents a "low" risk to the public and a "negligible" risk to workers. One potential source of an external event fire for the A625 facilities would be an accident at the nearby fueling stations (e.g., ethanol, compressed natural gas). B695 Segment of DWTF had no unique impact on the DWTF Storage Area facilities due to separation distances and the partition between B696S and B696R.

Accident at Nearby Facility (DWTF & A625: EE-4)

The frequency of an accident (e.g., explosion) occurring at a nearby facility releasing hazardous material or creating a projectile that could impact TRU waste stored at the DWTF or A625 Waste Storage Facilities is considered "extremely unlikely." The consequences to the co-located worker and public are considered "low." Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. The nature of an accident at a nearby facility provides indication of the event, which further supports a reasonable detection and emergency response to any event. This represents a "negligible" risk to the public and the worker.

Natural Gas Line Breach (DWTF & A625: EE-5)

The frequency of a capped off natural gas line breach and ignition causing a fire that impacts stored TRU waste in A625 Waste Storage Facilities is considered "extremely unlikely." The consequences are considered "low" for the co-located worker and "moderate" for the public. Site facility worker consequences are consistent with the co-located worker consequences. The "moderate" public consequence estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. The inherent aromatic warning for piped natural gas leaks provides indication of the event, which further supports a reasonable detection and emergency response to any event. This represents a "low" risk to the public and the worker.

Overhead Power Line (A625:EE-6)

The frequency of an overhead high voltage power line dropping into the yard, remaining energized, and inducing a fire that impacts approved TRU waste containers in A625 Waste Storage Facilities is considered "extremely unlikely." The consequences to the worker are considered "low" and the public are considered "moderate." Site facility worker consequences are consistent with the co-located worker consequences. The "moderate" public consequence estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity. Worker injuries would primarily be the result of electrical trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure and a worker would have to remain in the plume for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. The circuit cutoff for shorted power lines provides indication of the event, which further supports a reasonable detection and emergency response to any event. This represents a "low" risk to the public and a "negligible" risk to the worker.

External Events Preventive and Mitigative Features

Candidate preventive and mitigative features for the external events include the following:

- A limit of 50 PE-Ci of radioactive material per container, with the exception of tritium which is limited to 2,000 Ci per container
- TRU waste staged outside the building will be limited to arrays with a maximum inventory of 200 PE-Ci per array and limited to 36 hours. Any one array of staged drums shall be separated from other arrays by no less than 10 feet.
- TRU waste will be stored in approved TRU waste containers.
- A minimum 20-ft separation between nuclear segments (Keep Clear area) is maintained.
- B696S/B696R partition.
- An emergency preparedness program for the Waste Storage Facilities to train employees on appropriate emergency response actions.

NATURAL PHENOMENA HAZARDS EVALUATION

Six natural phenomena hazard (NPH) events were evaluated in the PrHA for this DSA for the DWTF and A625 Waste Storage Facilities. These include:

1. a design basis wind scenario,
2. two lightning scenarios,
3. a design basis flood scenario
4. two design basis earthquake scenarios, and

Design Basis Winds (DWTF: NPH-1, A625: NPH-1)

The design basis wind for a PC-2 facility at LLNL is discussed in Chapter 1. In the case of a facility not rated to meet PC-2 wind criteria, the structure could collapse, crushing some containers; thus, TRU waste is not stored in non-PC-2 buildings. Design basis wind events impacting inventories in the building or the yard and causing stacked containers to breach and release radioactive material are considered “unlikely” in the PrHA for DWTF and A625 Waste Storage Facilities. The consequences to the co-located worker and public are considered “low” for DWTF and A625 Waste Storage Facilities. Site facility worker consequences are consistent with the co-located worker consequences. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because significant winds would enhance dispersion and significantly lower the potential exposure. A worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. A significant wind that results in the release of radioactive material provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The resulting risk to the public and the worker is considered “low” for DWTF and A625 Waste Storage Facilities.

Lightning Strike (DWTF & A625: NPH-2, NPH-3)

Lightning strike scenarios resulting in a facility fire or a yard fire impacting TRU waste inventories are both considered “extremely unlikely” for DWTF and A625 Waste Storage Facilities. Over a recent 10 year period, only four lightning strikes were recorded within a 2 mile radius of LLNL. There were no recorded instances of lightning strikes within the boundaries of LLNL during this 10 year period. The consequences are considered “moderate” to the public and “low” to the co-located worker for DWTF and A625 Waste Storage Facilities. Site facility worker consequences are consistent with the co-located worker consequences. The “moderate” public consequence estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity. Worker injuries would primarily be the result of electrical trauma rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because the thermal input would tend to loft the plume reducing the potential exposure. A worker would have to remain in the plume for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. A lightning strike in a nuclear segment provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The resulting risk to the public is considered "low" and risk to the worker is considered "negligible" for DWTF and A625 Waste Storage Facilities.

Design Basis Flood (DWTF & A625: NPH-4)

The two sources of flooding at LLNL are from the Arroyo Las Positas and the Arroyo Seco. The DBFl for a PC-2 facility at LLNL, with a 2000-year return period, is considered "unlikely" for DWTF and A625 Waste Storage Facilities. The flood analysis for DWTF (Lin 1998) estimates the overflow of the Arroyo Las Positas during a 2,000 year flooding event to impact the DWTF with floodwater approximately nine inches above the existing grade of the DWTF site. The conclusions show no major flood damage to buildings within the DWTF from a 2,000 year frequency precipitation event. Based on the flood analysis for the B231 vault (Majumdar 2001), it is expected that B625 will have no major flood damage to buildings from a 2000-year flood. It is assessed that some degree of drum leakage could occur from a 2,000-year flooding event of the facility. This could result in the leaking of a portion of the drums' radioactive contents. The consequences to the co-located worker and the public are considered "low" for DWTF and A625 Waste Storage Facilities. Site facility worker consequences are consistent with the co-located worker consequences. Worker injuries would primarily be the result of consequences from a flood rather than the result of radioactive uptake. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because flooding conditions significantly limit the potential for the release of airborne particles. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. A significant flood provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The resulting risk to the public and worker is considered "low" for DWTF and A625 Waste Storage Facilities.

Earthquake (DWTF & A625: NPH-5, NPH-6)

The design basis earthquake for a PC-2 facility at LLNL is 0.57 g with a 1000-year return period (DOE 1996a), and is considered "unlikely" for DWTF and A625 Waste Storage Facilities. The most probable scenarios in a seismic event include: 1) the toppling of stacked containers resulting in a spill, and 2) the toppling of stacked containers resulting in a spill with a subsequent fire and buoyant release. All facilities that store TRU waste meet PC-2 seismic criteria. In addition, the B625 crane has seismic restraints. Unmitigated consequences for a spill and fire are considered "moderate" to the public and "low" to the co-located worker. These consequence estimates account for potential interactions between building utilities and other attachments with the containerized TRU waste inventories. Site facility worker consequences are consistent with the co-located worker consequences. The "moderate" public consequence estimation follows from the relatively more conservative consequence severity levels for the public as identified in **Table 3-2**. In addition, the public would not be aware of the accident and could unknowingly remain in the vicinity. Workers closer to the point of release could receive a higher dose as compared to the doses evaluated at the onsite receptor location, they are qualitatively judged to have a minimal impact on potential consequences because a worker would have to remain in the vicinity of the release for an extended period of time (hours) in order to receive a significant exposure. This is only likely where a worker is incapacitated, in which case physical injuries would be much greater than any radiological consequence. It is reasonable to assume that the workers will observe the accident and leave the scene in a timely manner. An earthquake provides an indication of the event, which further supports a reasonable detection and emergency response to any event. The potential risk due to the seismic accidents is considered "low" to the public and the worker after crediting that containers shall not be stacked more than two levels high and limiting waste containers and pallets in TRU waste storage areas to metal.

Natural Phenomena Hazards Preventive and Mitigative Features

Candidate preventive and mitigative features for the NPH events include the following:

- A limit of 50 PE-Ci of radioactive material per container, with the exception of tritium which is limited to 2,000 Ci per container
- TRU waste staged outside the building will be limited to arrays with a maximum inventory of 200 PE-Ci per array and limited to 36 hours. Any one array of staged drums shall be separated from other arrays by no less than 10 feet.
- B625 and B696R building structural systems
- TRU waste will be stored in approved TRU waste containers
- An administrative control ensures that TRU waste containers shall not be stacked more than two levels high and that approved TRU waste containers exceeding a nominal height of 4-ft are not stacked. Any TRU waste drums stacked at the second level that topple in an earthquake are designed to remain intact
- Combustible loading controls to minimize and control the use of combustible materials, including limiting waste containers to metal containers on metal pallets in TRU waste storage areas.

Periodic structural inspection, seismic restraints on the crane, and post-natural phenomena inspection are additional mitigative provisions.

3.3.2.3.1 Planned Design and Operational Safety Improvements

No specific design or operational safety improvements were identified as a result of the hazard evaluation.

3.3.2.3.2 Defense-in-Depth

This section summarizes significant aspects of the defense-in-depth philosophy as implemented to provide safety at the Waste Storage Facilities. This section does not provide a comprehensive list of defense-in-depth items listed in the PrHA, but consists of both design features and safety management programs. Defense-in-depth includes safety-significant SSCs and ensures that the health and safety of the public and workers are not adversely impacted by the design and operation of the Waste Storage Facilities.

Safety programs described in Chapter 6 through Chapter 17 assure that the occupational exposures to hazardous and radioactive materials are maintained as low as reasonably achievable below the regulatory limit during normal operations and most abnormal conditions. In the event of an accident, safety-significant SSCs and specific administrative controls identified and maintained in the TSR assure that the potential dose consequences are mitigated to protect the environment and the health and safety of the public and the workers.

Thus, the defense in depth philosophy as implemented in the Waste Storage Facilities consists of safety programs, i.e., institutional safety provisions and organizational discipline, to assure operational safety and to maintain safety significant SSCs that protect the environment and the health and safety of the public and the workers in the unlikely event of an accident. Safety significant items are discussed further below. The defense in depth is commensurate with the potential hazards consistent with the graded approach.

Consistent with the defense in depth philosophy described above, fire suppression systems are installed in the Waste Storage Facilities to control the fire growth and, thus, to prevent fire propagation in the event of a fire. Although fire suppression systems are not specifically credited to reduce the risk for any potential fires in the PRHA, building fire suppression systems in TRU storage areas are considered to provide significant risk mitigation. Accordingly, as a part of the fire protection program, fire suppression systems are inspected, tested, and maintained in accordance with the applicable NFPA requirements.

The potential dose consequences associated with postulated accidents that have been identified for further evaluation in accordance with DOE-STD-3009-94, Change Notice 3, are analyzed in detail in Section 3.4.

In summary, defense-in-depth controls are engineered and administrative provisions, and they serve either a mitigative or preventive function. The control types given in the PrHA constitute initial conditions of scenario development, controls credited for reducing frequency or consequence, and other defense-in-depth controls that contribute to best management practices.

Safety-Significant Structures, Systems, and Components

On the basis of the PrHA, the following passive SSCs have been designated as safety significant:

- Approved TRU waste containers: The various types of storage containers represent the innermost design defense-in-depth measure. All TRU waste is packaged in approved TRU waste containers as described in Section 4.4.1.3. Accumulation of flammable gases within the containers is mitigated by the presence of vents on most TRU waste drums. TRU oversize boxes and LLW/TRU conversions (see Section 4.4.1.3) are not required to be vented.
- B625 and B696R structures: The facility structures are designed and constructed to withstand PC-2 earthquake and wind.
- B696S/B696R partition: The partition between B696R and B696S is required for segmentation purposes.

Chapter 4 discusses the safety function for each of these safety significant SSCs.

Technical Safety Requirements (TSRs)

TSR coverage is required for design features and administrative controls that support the defense-in-depth concept. The design features are the PC-2 structure of the buildings that store TRU waste (B696R and B625), the B696S/B696R partition, and approved TRU waste containers for storage of TRU waste. The following are specific administrative controls at the Waste Storage Facilities:

- A limit of 50 PE-Ci of radioactive material per container; except for tritium, which is limited to 2,000 Ci per container. The drum loading and configuration will remain within the NEPA bounding consequence calculations.
- The fissile material inventory per container is limited to 200 Pu-239 FGE.
- TRU waste staged outside the building will be limited to arrays with a maximum inventory of 200 PE-Ci per array and limited to 36 hours. Any one array of staged drums shall be separated from other arrays by no less than 10 feet.
- TRU waste will be stored in approved TRU waste containers.
- Stacking of approved TRU waste containers is limited to a maximum of two high. Approved TRU waste containers exceeding a nominal height of 4-ft are not stacked.
- TRU waste containers will not be opened in the Waste Storage Facilities.
- TRU waste containers will not be staged less than 130 m from the Greenville Road fence line (i.e., east of B693 structure).
- Only waste in metal containers and on metal pallets is allowed in TRU waste storage areas.
- TRU waste storage is limited to B696R and B625.

The following are programmatic controls at the Waste Storage Facilities:

- A criticality safety program, further discussed in Chapter 6, to ensure that the potential for an inadvertent criticality event is precluded.
- A single container inventory limit (SCIL) program for chemical waste, invoked through the hazardous material protection program and further discussed in Chapter 8.
- A requirement for an inspection program for safety significant SSCs is invoked through an in-service inspection and test program, further described in Chapter 10, Initial Testing, In-Service Surveillance, and Maintenance.
- A fire protection program, further described in Chapter 11, Operational Safety, implements combustible loading controls to minimize and control the use of combustible materials at the Waste Storage Facilities and establishes Keep Clear areas for a minimum 20-ft separation between nuclear segments.
- An emergency preparedness program for the Waste Storage Facilities, including appropriate emergency response actions, is further described in Chapter 15, Emergency Preparedness Program.
- A training program that includes qualification and certification of forklift and crane operators.
- A traffic control program to provide protection from vehicular traffic for TRU waste in the yard by limiting the speed of vehicles in the Waste Storage Facilities.

Further TSR derivation information is provided in Chapter 5.

3.3.2.3.3 Worker Safety

The major features protecting workers from hazards associated with accidents occurring during facility operation are similar to those documented in the defense-in-depth section, Section 3.3.2.3.2. This includes the description of safety-significant SSCs and administrative controls requiring TSRs.

The hazards to the Waste Storage Facilities workers, associated with normal and abnormal conditions, include potential exposure to radionuclides, hazardous materials, and safety and health hazards. Radiation exposure can occur with radioactive materials within the waste containers or from exposure to contamination that may exist on the surfaces of waste containers or waste-handling equipment. The hazardous components of hazardous, mixed, and combined wastes include corrosives, metals, and organics. The sources of safety and health hazards include electrical hazards, motion hazards, gravity-mass hazards, and pressure, heat, and noise hazards.

RHWM implements and maintains a full set of safety management programs that are described further in Chapters 6 through 17. As stated previously, the focus of the hazards analysis is on potential accident conditions. From the list of safety management programs, the following were considered the most significant for worker safety. These are included in the TSRs and are described in later chapters of this DSA.

- **Criticality Safety Program** (DSA Chapter 6) – Ensures that a criticality event is not credible by setting appropriate inventory limits.
- **Radiation Protection Program** (DSA Chapter 7) – Ensures that workers are provided adequate protection from radiological hazards, including training and monitoring.
- **Hazardous Material Protection Program** (DSA Chapter 8) – Ensures that workers are provided adequate protection from hazardous materials, including training.
- **In-service Inspection & Test and Maintenance Programs** (DSA Chapter 10). Ensures the integrity of the Safety Significant SSCs. Inspections are performed by qualified personnel using documented procedures.
- **Fire Protection Program** (DSA Chapter 11) – Ensures that the facility has provisions in place for combustible loading control and adequate fire fighting capabilities, and separation to protect segmentation.
- **RHWM Training Program** (DSA Chapter 12) – Ensures that operators are qualified to perform their specified duties and thereby minimize exposure to hazardous conditions.
- **Emergency Preparedness Program** (DSA Chapter 15) – Ensures that workers are aware of the proper response actions in the event of an emergency.
- **Configuration Management Program** (DSA Chapter 17) – Ensures protection of workers and the public by establishing the mechanisms for consistency between design requirements, physical configuration, and documentation of configuration items.

Procedures are an intrinsic part of the above programs.

3.3.2.3.4 Environment Protection

Protection of the environment is the result of design and operational features that reduce the potential for large releases of radioactive waste to the environment. Impacts to the environment from the scenarios discussed in this chapter are considered less than the impacts to the public. Controls identified in the PrHA are considered sufficient to address the impacts to the environment.

3.3.2.3.5 Accident Selection

Accident selection identifies the unique and representative potential accidents that are included in the accident analysis. Representative accidents bound a number of similar accidents that typically have lower consequences or frequencies. The selection criteria are consistent with the Nuclear Safety Risk Ranking and Control Selection Guidelines provided by the DOE Safety Basis Special Project Team (Nelson 2003) as described in Section 3.3.1.2. Unique accidents are those that cannot be bounded by representative accidents due to the nature of the hazard or accident progression. A potential accident identified with a high or moderate risk ranking is either brought forward for accident analysis or is bounded by a representative accident identified for accident analysis. This designation is specifically identified in the comment field of the PrHA. No high risk mitigated accident scenarios were identified that released radioactive material.

From the hazard analysis, six scenarios were identified as the bounding accidents requiring further evaluation in Section 3.4, “Accident Analysis,” as shown below. The selected accidents were of different accident types with the largest predicted dose consequences to the public. These accidents were selected irrespective of the qualitative assessment of the likelihood of occurrence and encompass the representative and unique accidents brought forward for accident analysis.

Deflagration of TRU Waste Container (DWTF WH-14; A625 WH-16) – A deflagration involving one container postulated due to ignition of flammable gas in an unvented TRU waste container. This is analyzed in Section 3.4.2.1.

Spill of TRU Waste Containers in Yard (DWTF & A625 WH-1A) – Spill postulated to occur from high-speed vehicle accident impacting pallets of staged TRU waste containers. The postulated spill in the yard bounds the inside the facility spill scenarios. This is analyzed in Section 3.4.2.2.

Fire Involving Stored TRU Waste Containers in Building (DWTF WH-10; A625 WH-12) – Fire postulated to occur from spilled flammable liquid in the building resulting in failure of multiple TRU waste containers. This is analyzed in Section 3.4.2.3.

Tritium Fire in Building (DWTF WH-12; A625 WH-14) – Although a tritium release is not the bounding radiological event, it is included because of the unique form of tritium (it can be released as a gas or a high vapor pressure liquid). Fire postulated to occur from spilled flammable liquid in the building resulting in failure of LLW containers containing tritium. As the primary form of high Curie tritium waste is either tritiated water adsorbed on molecular sieve or metal tritides, both of which are contained in stainless steel containers, tritium as either molecular tritium (HT or T_2 gas) or tritiated water (HTO or T_2O) would be released at a reasonably rapid rate only in a fire scenario. Thus, a fire bounds a spill. This is analyzed in Section 3.4.2.4.

Large Fire Involving Staged TRU Waste Containers in the Yard (DWTF WH-8A; A625 WH-10A) – Spill with subsequent fire postulated to occur from high-speed vehicle accident impacting pallets of staged TRU waste containers. This is analyzed in Section 3.4.2.5.

Aircraft Crash in Building Storing TRU Waste (A625 EE-2) – A general aviation, fixed wing single engine aircraft crashes into a building resulting in a spill of TRU waste containers from the impact. A subsequent fire from aviation gasoline is also postulated to occur, impacting additional TRU waste containers within the building. This scenario was identified as "extremely unlikely" and therefore a DBA for A625. The bounding release will occur in B625.

The remaining operational, external, and NPH events were qualitatively determined to be of lower consequence or lower risk or, if having equal consequence, as having lower risk because of lower likelihood of occurrence.

Of the potential events qualitatively evaluated in the hazard analysis, only one postulated mitigated operational accident involves multiple pallets of TRU containers. This is a compartment fire resulting in failure of multiple TRU containers leading to radioactive release. No operational event qualitatively analyzed in the hazard analysis has the potential to involve the entire facility inventory.

The number of failed TRU containers in the postulated compartment fire accident is established by the magnitude and the severity of the potential fire, i.e., the predicted worst temperature must exceed 600°C for catastrophic failure of some drums as shown experimentally in WHC-SD-WM-TRP-249. For the most severe case analyzed in Section 3.4.2.3, the predicted maximum temperature is less than 400°C for the postulated 4-MW fire involving a pool of flammable liquid. The total number of failed TRU waste containers is limited to ten with an assumed radioactive inventory of 50 PE Ci each, and is independent of a specific location within the Waste Storage Facilities. The results of the analysis demonstrated that the fire severity from the postulated fuel pool fire would not lead to failure of all TRU waste containers even within the same compartment for the smallest of compartments in the Waste Storage Facilities.

Operationally, because of spatial limitations, radioactive waste containers, e.g., 55-gal drums, occupy nearly all available storage space in the buildings. This restricts the quantity of transient combustibles in each building. While a conservative combustible loading limit is established in the TSR to preclude fire propagation to adjacent compartments the actual combustible loading in each building is significantly below the established limit. In addition, ignition sources are limited because types of operations are mostly related to storage. Therefore, a potential fire that involves the entire facility inventory is not credible.

Furthermore, the fire protection program as described in Chapter 11 minimizes the combustible loading and ignition sources. Fire suppression systems will limit the fire growth in the unlikely event of a catastrophic programmatic failure. Fire-rated partitions in a building preclude the potential for fire propagation. The programmatic provisions and SSCs in combination provide further assurance that radioactive release from potential fires is minimized.

Natural phenomena hazard and external event scenarios can only affect limited material at risk based on the physical aspects related to the initiating event and subsequent enabling events through the progression of the accident scenario. The unmitigated accident scenarios analyzed have their MAR established considering these basic physical properties for each accident scenario. Some of the basic physical properties include the capped off natural gas line, separation distance from potential hazards (e.g., refueling stations), and the physical limitation of how much material the hazard can affect (e.g., aircraft engine). In addition, facilities that may not withstand a design basis accident and areas designated for storage of flammable liquids will not be used for storage of TRU waste. Thus, external or natural phenomena events qualitatively analyzed in the hazard analysis can only affect limited MAR based on the physical aspects related to the initiating event and subsequent enabling events through the progression of the accident scenario.

Although mitigated chemical spill or fire release scenarios identified in the PrHA represent a "moderate" consequence to the public, these accidents have a "low" risk and are not selected for accident analysis. The SCIL Program, which is a portion of the Hazardous Material Protection Program, is used to control the inventory of hazardous chemicals in waste. The SCIL limits the consequences to the public and the co-located worker. The Hazardous Material Protection Program ensures the Waste Storage Facilities are Low Hazard facilities and provides adequate protection of the public, the co-located worker and the site facility worker from chemical releases. The Hazardous Material Protection Program and the SCIL Program are further discussed in Chapter 8.

3.4 Accident Analysis

This section presents the analysis of the postulated accidents selected from the hazard analysis described in Section 3.3.2.3.5, "Accident Selection." An evaluation was performed to assess the relative risk for each postulated accident. The methodology to determine the dose consequences of the postulated accidents is discussed in Section 3.4.1. Analyses of the dominant accident scenarios, including controls credited in each accident scenario, are presented in Sections 3.4.2.1 through 3.4.2.5 and 3.4.3.3.

3.4.1 Methodology

The accident analysis methodology complies with the guidelines in DOE-STD-3009-94, Change Notice 3. For each bounding accident, the accident scenario is developed to enable characterization and quantification of the source term. The dose consequence analysis is based on the source term analysis and the results of the atmospheric diffusion analysis. The source term is calculated by:

$$ST = MAR \times ARF \times RF \times DR \times LPF$$

where *MAR* is the quantity of radioactive inventory at risk, *ARF* and *RF* are airborne release fraction and respirable fraction from DOE-HDBK-3010-94 (DOE 1994), respectively, *DR* is the damage ratio, and *LPF* is the leakpath factor. For unmitigated cases, a value of unity is assumed for *LPF*.

The source term is then multiplied by the potential dose consequence for unit of radioactivity released to the environment yielded by the atmospheric diffusion analysis. For postulated accidents involving plume buoyancy, the atmospheric diffusion analysis was performed using the computational code MACCS2 (SAND97-0594) based on the site-specific meteorological data, conservative terrain conditions, and building dimensions to maximize the dose consequences. The analysis yielded dose consequences for a unit radioactive release as a function of distance and the plume sensible heat. MACCS2 was also used for postulated accidents not involving plume buoyancy.

Radiation dose consequences are the product of the source term and the dose to source term ratio. Dose consequences are expressed in total effective dose equivalent (TEDE), which consists of the effective dose equivalent (EDE) for radiation exposure from external sources and the 50-year committed effective dose equivalent (CEDE) for radiation exposure from internal sources absorbed by inhalation and ingestion. Unmitigated and mitigated dose consequences are reported for the co-located worker (at 100 m) and the maximally-exposed offsite individual (MOI) located at the nearest site boundary on Greenville Road. The potential consequences to the site facility workers were qualitatively evaluated in the hazard analysis in Section 3.3.

The accident analysis in this chapter has been simplified consistent with the graded approach. The following conservative and simplifying assumptions were used in the analysis:

- A leak-path factor (LPF) of unity is assumed for buildings. That is, the radioactive particulate entrained in the exhaust ventilation flow is not reduced even though the release that would occur from the buildings would result in reduction of the LPF by gravitational settling and agglomeration.
- The bounding ARF×RF (airborne release fraction × respirable fraction) from the DOE-HDBK-3010-94, "Airborne Release Fractions/Rates and Respirable Fractions for Non-Reactor Nuclear Facilities," is used for the postulated accidents for simplicity and conservatism. As an example, for burning of packaged contaminated waste, a combined value of $5\times10^{-4}\times1$ is recommended as the bounding value for ARF×RF in DOE-HDBK-3010-94.
- Dose conversion factors (DCFs), whether in Federal Guidance Report (FGR) No. 11 (FGR 11) or International Commission on Radiological Protection (ICRP) 72 (ICRP 72), are based on a particle size distribution of 1 μm AMAD (activity median aerodynamic diameter). The RF in DOE-HDBK-3010-94 is the portion of the airborne particulate with sizes less than 10 μm AED (aerodynamic equivalent diameter).

MACCS2 uses inhalation DCFs in FGR 11. For Pu^{239}, the CEDE DCF for inhalation class Y, which is appropriate for the materials in the Waste Storage Facilities, is 3.08×10^{8} rem/Ci in FGR 11. In comparison, the DCF in ICRP 71/72 (ICRP 71, ICRP 72) for Type S, equivalent to Class Y in FGR 11, is 1.6×10^{-5} Sv/Bq (5.9×10^{7} rem/Ci) for 1 μm AMAD. Data from ICRP 71/72 was issued by the U.S. EPA as Federal Guidance Report No. 13 (FGR 13) in September 1999.

The DCF is based on solubility of the chemical form of plutonium. Type S in ICRP 72 (Solubility Class Y in FGR 11) is assumed for all TRU waste scenarios since most of the contamination is expected to be plutonium oxide. Type M in ICRP 72 (Solubility Class W in FGR 11) is appropriate for nitrates or other soluble plutonium compounds, e.g., plutonium chloride, which have higher DCFs as discussed above. However, the amount of soluble plutonium contamination on most TRU wastes is expected to be minimal. Plutonium nitrate contamination from aqueous plutonium recovery processes is expected to oxidize over time from exposure to air; plutonium fluoride readily decomposes. Consequently, plutonium nitrate, plutonium chloride, and plutonium fluoride or other soluble plutonium compounds are not expected to be significant portions of the radioactive inventory.

Even if the particle size distribution is conservatively ignored, there is a reduction factor of 5.2 when ICRP 72 data are used for Pu^{239} relative to FGR 11. Based on the results from MACCS2 for Pu^{239}, the estimated dose consequences are manually reduced by a factor of 5.2 in this analysis as a means to employ the DCFs in ICRP 72. There is a slight increase (factor of 1.04) when ICRP 72 data are used for tritium. Based on the results from MACCS2 for tritium, the estimated dose consequences are manually increased by a factor of 1.04 in this analysis as a means to employ the DCFs in ICRP 72. Based on the factors discussed, radiation dose consequences predicted in the accident analysis are conservative.

For the rare cases where Am^{241} may be loaded in drums, the dose conversion factors in ICRP 72, show that the predicted dose consequences from potential accidents involving Am^{241} would be nearly the same or lower than those involving Pu^{239}. Therefore, no adjustment is needed to account for Am^{241}. Based on the recent health physics data in ICRP 72, there would be no additional impact on the health and safety of the public and the workers from exposure to Am^{241}.

In order to provide a bounding analysis, the MAR in each TRU waste container is assumed to be 50 PE-Ci.

As described in Chapter 2, TRU waste may be staged and stored in a number of locations in the Waste Storage Facilities. Activities and operations occurring in the Waste Storage Facilities are sufficiently similar such that postulated accident scenarios do not change substantively based on the storage facility or staging location. B625 and B696R are the only buildings currently authorized for storing TRU waste. Although RHWM does not currently plan to store TRU waste at B693, B693 is the closest waste storage facility to the LLNL site boundary that is appropriate for storing TRU waste if authorized by the safety basis. In addition, TRU waste containers will not be staged less than 130 m from the LLNL site boundary (i.e., east of the B693 structure). As a result, dose consequences to the MOI from postulated accidents involving staged or stored containers occurring at B693 were found to bound those from other Waste Storage Facilities storing or staging TRU waste as shown in **Tables 3-6 and 3-7**. The accidents presented in Section 3.4.2 are, therefore, postulated to occur at B693 even though RHWM does not currently plan to store TRU waste in this building.

Dose consequences for co-located workers at 100 m for accident scenarios involving buoyant plumes are based on the bounding results from **Table 3-7** (i.e., B625). The variation in the results for the 100 m data for buoyant plumes is due to the inclusion of building wake effects in the MACCS2 model, which is influenced by the plume sensible heat, building dimensions, and the meteorological condition. Non-buoyant plume dose consequence estimates for co-located workers at 100 m are independent of the location of the release since they are not impacted by building specific information.

Table 3-6. Dose Consequence Values from Ground Release of Non-Buoyant Plume

Location	MOI Dose (rem/PE-Ci)	Co-located Worker Dose @100 m (rem/PE-Ci)
B625	7.5	41
B693	22	41
B696R	20	41

From WM/FS-WSF-0402.

Table 3-7. Dose Consequence Values from Ground Release of Buoyant Plume

Location	MOI Dose (rem/PE-Ci)		Co-located Worker Dose [b] @100 m (rem/PE-Ci)	
Magnitude of Fire	**9 MW [a]**	**4.1 MW [b]**	**9 MW [a]**	**4.1 MW [b]**
B625	2.6	4.6	11	18
B693	3.9	6.6	5.8	10
B696R	3.8	5.0	4.7	6.8

[a] Data from HC/AB-B696-0203.

[b] Data from WM/FS-WSF-0404.

3.4.2 Design Basis Accidents

The PrHA identified events with potential radiological consequences that require further analysis. The Accident Analysis requires a radiological analysis to determine the impact to the MOI.

This section analyzes design basis accidents to quantify consequences and compare them to the evaluation guideline. From the hazard analysis, five design basis accidents were identified as the bounding accidents requiring further evaluation in the accident analysis:

- A deflagration due to ignition of flammable gas in an unvented TRU waste container.
- A spill in the yard postulated to occur from a high-speed vehicle accident impacting pallets of staged TRU waste containers. The postulated spill in the yard bounds the inside the facility spill scenarios.
- A postulated fire involving spilled flammable liquid in the building resulting in failure of multiple TRU waste containers.
- A postulated fire involving spilled flammable liquid in the building resulting in failure of LLW containers containing tritium.
- A spill in the yard with subsequent fire postulated to occur from a high-speed vehicle accident impacting pallets of staged TRU waste containers.
- An aircraft crash into a TRU waste storage building causing a fire and resulting in failure of multiple TRU waste containers.

3.4.2.1 Deflagration in TRU Waste Container

Container handling is a routine part of the operations in the Waste Storage Facilities. TRU waste is packaged in polyethylene bags and contained in approved TRU waste containers. A potential exists for the buildup of radiolytic hydrogen in sealed TRU waste containers.

Based on the results of the hazard analysis in Section 3.3, radiolytic hydrogen buildup and deflagration in TRU waste containers is identified as one of the scenarios to be analyzed in the accident analysis. Consequently, this section provides a bounding analysis of a deflagration scenario to ensure that the postulated event does not adversely impact the health and safety of the public and the workers.

3.4.2.1.1 Scenario Development

A deflagration of radiolytic hydrogen scenario can compromise the structural integrity of a drum and lead to an uncontrolled release of radioactive contaminant.

The duration to reach the lower flammability limit (LFL) of 4% hydrogen by volume is calculated as 1,480 hours assuming a 20% void space in a hermetically sealed 55-gal drum containing 8 PE-Ci (HC/AB-B696-0202). Adjusting the equation in the referenced calculation to account for 50 PE-Ci drums, the duration to reach the LFL of 4% hydrogen by volume becomes approximately 237 hours. This is a conservative estimate because a larger container or a larger void space in a 55-gal drum would require a longer duration to reach the LFL. For a larger Standard Waste Box or a larger void volume in a 55-gal drum, the duration to reach LFL will increase linearly—again, only if the container is hermetically sealed. Based on the radioactive inventory in storage, and the required duration and conditions to reach LFL, the postulated radiolytic hydrogen deflagration involving a hydrogen concentration above LFL in one container with 50 PE-Ci is considered "unlikely" for unvented containers.

3.4.2.1.2 Source Term Analysis

The assumed container inventory of 50 PE-Ci is used as the MAR. The bounding airborne respirable fraction (ARF×RF) of $1\times10^{-3}\times1$ is recommended in Section 5.1 of DOE-HDBK-3010-94 for "venting of pressurized gases over contaminated, combustible waste…" because of "flexible nature, which does not provide a rigid surface for airflow to act upon" the contaminated waste in containers. It is stated in the same section that ARF×RF of $1\times10^{-3}\times1$ are "applicable only to the portion of waste surfaces that are actually exposed."

The potential combustion energy from a deflagration of a hydrogen-air mixture at LFL in the 20% void space is 20.2 kJ (19 Btu) (HC/AB-B696-0202). For a deflagration involving a stoichiometric hydrogen-air mixture, there is no oxygen remaining in the drum to sustain combustion. Even at the stoichiometric concentration of 29.6% by volume of hydrogen in air, however, the potential combustion energy from a deflagration is 150 kJ (142 Btu). A typical drum is loaded in excess of 100 lb. The temperature attained by a nominal 1-lb of contaminated cellulosic materials is 163°C, assuming adiabatic heat transfer of the entire combustion energy, from a stoichiometric hydrogen-air mixture deflagration. This is not close to the exothermic pyrolytic decomposition temperature of 280°C or a quantity of polyethylene (PE) to the 1% thermal degradation temperature of 275°C, which is not sufficient to sustain a fire involving PE.

There is a lower oxygen limit (LOL) of around 10% to 15%, depending on the materials, below which flaming combustion cannot be sustained. This means that the oxygen concentration in the drum after the deflagration must be above the LOL for combustion of contaminated waste. For hydrogen, the LOL is theoretically 5% by volume. This is obtained by taking the upper flammability limit of 75% by volume for hydrogen and figuring the oxygen concentration at the UFL for hydrogen (0.25×0.21). For complex hydrocarbons, e.g., plastics and cellulosic materials, the LOL is on the high side, e.g., 15% by volume. Assuming 10% as the LOL for the contaminated combustibles and ignoring the thermal consideration discussed above, the maximum hydrogen concentration for even a possibility of an ensuing fire involving contaminated waste is theoretically 17% by volume. However, it was shown above that the thermal consideration at stoichiometry of 29.6% does not support further reaction.

There is a period of venting, an outward flow of gases, in an explosion whether it is from a building or from a container like a 55-gal drum. During this, albeit short, period, there is no inward flow of fresh air as dictated by the Bernoulli equation. Thus, a fire following a hydrogen deflagration is not postulated consistent with the physical limitation.

According to vendor data for Type A drums, the typical hydrostatic pressures at failure range from 170 kPa (24 psig) to 250 kPa (36 psig) (Yang 2002). The computed AICC (adiabatic, isochoric complete combustion) pressure from a deflagration of hydrogen at the lower flammability limit (LFL) is 23 psig (HC/AB-B696-0202). Actual pressure measurements indicated that the deflagration is less than 90% of the predicted AICC pressure at low hydrogen concentrations up to 15% by volume. Therefore, a hydrogen deflagration at LFL is not likely to compromise the integrity of a container. While not likely to fail at LFL, the postulated deflagration is conservatively assumed to lead to failure of drum integrity.

The likely location for accumulation of radiolytic hydrogen is at or near the top of a container because of buoyancy. The exposed surface of contaminated waste would thus be limited. Based on the provision in DOE-HDBK-3010-94 to apply “only to the portion of waste surfaces that are actually exposed,” only a nominal portion of waste surfaces would be exposed directly to a deflagration pressure. As discussed above, drum failure is not likely for a deflagration involving low hydrogen concentrations; thus, a DR of 0.2 is used. A *LPF* of unity is used for unmitigated analysis.

The source term is then:

$$\begin{aligned} ST &= 50\,PE-Ci\times\left(1\times10^{-3}\right)\times1\times0.2\times1 \\ &= 1.0\times10^{-2}\,PE-Ci \end{aligned}$$

The most probable mechanism by which a radioactive release can occur subsequently from the facility is by entrainment in the exhaust ventilation flow, although a value of unity must be assumed for the leakpath factor for the unmitigated scenario consistent with Appendix A of DOE-STD-3009-94 (DOE 2006). Gravitational settling and agglomeration would reduce the actual value for the *LPF*.

3.4.2.1.3 Consequence Analysis

This analysis was performed assuming the release occurs at B693 in order to bound the dose consequence results (see Section 3.4.1). The dose consequence result from MACCS2 is 22.1 rem/PE-Ci at the nearest site boundary from B693 (WM/FS-WSF-0402). The radiation dose consequence to the MOI is then:

$$TEDE = 1.0 \times 10^{-2} \text{ PE-Ci} \times 22.1 \ \text{rem}/_{\text{PE-Ci}}$$
$$= 0.2 \ \text{rem}$$

For estimating the potential dose consequence to the co-located worker, the dose consequence result from MACCS2 at 100 m from the release is 40.6 rem/PE-Ci (WM/FS-WSF-0402). The radiation dose consequence to the co-located worker is then:

$$TEDE = 1.0 \times 10^{-2} \text{ PE-Ci} \times 40.6 \ \text{rem}/_{\text{PE-Ci}}$$
$$= 0.4 \ \text{rem}$$

If the leakpath factor is reduced to less than unity because of agglomeration and gravitational settling as discussed in Section 3.4.2.1.2, the source term would be reduced linearly. For example, a *LPF* of 0.5 will reduce the source term to 5×10^{-3} PE-Ci. The potential offsite dose consequences would be reduced to approximately 0.1 rem.

For the type of postulated accidents, sufficient energy is not available to change the particle size distribution already present in the container. The analysis implicitly assumed that the entire radioactive inventory is respirable even though respirable particulate may be minimal.

The dose consequence from the postulated deflagration bounds that of a single drum spill, which is a contamination event. This confirms that a spill inside the facility is a contamination event that does not pose a significant impact on the health and safety of the public.

3.4.2.1.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public was 0.2 rem. This is well below, and is considered not to "challenge," the evaluation guidelines of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.1.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated deflagration, which bounds those of a single drum spill. Although the PrHA identified the TRU waste container maintenance program as a credited control for the DWTF WH-14 unvented TRU waste container deflagration scenario, the analysis shows that the potential unmitigated consequences for the postulated deflagration are "low" for the public and the workers. The risk associated with this scenario is also "low" to the public and the workers. Therefore, the TRU waste container maintenance program is not required to mitigate the consequences of the postulated deflagration.

Containers provide the means to packaging contaminated waste for transport and handling and provide defense in depth in postulated accidents. In addition, an inventory of 50 PE-Ci per container was assumed in the analysis. TRU waste containers and inventory limits are captured in the TSR to ensure that the conclusion of the analysis remains valid.

Vented TRU waste containers and the TRU waste container maintenance program provide defense in depth to prevent or to mitigate the consequences of the postulated deflagration in the Waste Storage Facilities.

3.4.2.2 Spill of TRU Waste Containers in Yard

Before containers are transported into facilities for storage, they are typically staged in the yard. An individual container or multiple containers can be transported at one time. Although the volume of the vehicle traffic in the Waste Storage Facilities is small and the speed of the vehicles is limited both spatially and by the facility speed limit, there is a potential for a collision involving vehicles that are used to transport containers from other facilities.

Based on the results of the hazard analysis in Section 3.3, a spill of an array of drums involved in a vehicle accident is identified as one of the scenarios to be analyzed in the accident analysis. Consequently, a bounding analysis involving an array of drums is performed in this section to ensure that the health and safety of the public and the workers are not adversely impacted by the postulated spill.

3.4.2.2.1 Scenario Development

A typical TRU waste container is capable of sustaining a 4-ft drop. A container falling from typical operating heights is not likely to lose structural integrity. The potential exists for a truck to collide with pallets of staged drums, breaching the integrity of the drums, and releasing radioactive material.

Based on the population of TRU waste containers and on-going activities in other facilities at LLNL, staging an array limit of drums totaling 200 PE-Ci is considered “anticipated to “unlikely.” A concurrent collision with a vehicle that is out of control resulting in damage to the array is considered “unlikely.”

An array limit of drums containing 200 PE-Ci is staged outside B693. The total inventory at risk is, thus, 200 PE-Ci. A high-speed truck is postulated to impact the array of staged drums. Although each drum is capable of sustaining a 4-ft drop, it is assumed that one-third of their contents are expelled. The expelled drum content is assumed strewn in the yard.

One control, traffic controls, was credited to further reduce the potential for a vehicle accident resulting in the spill of TRU waste in the yard. When traffic controls are included as a preventer in the accident sequence, the estimated frequency of the accident decreases from “unlikely” to “extremely unlikely.”

3.4.2.2.2 Source Term Analysis

An array limit containing a total of 200 PE-Ci is used as the *MAR*. The bounding airborne respirable fraction (ARF×RF) of $1\times10^{-3}\times0.1$ is recommended in Section 5.1 of DOE-HDBK-3010-94 for “the situation where the combustible material is packaged in a relatively robust container (e.g., hard pail, drum) that is opened or fails due to impact with the floor or impaction by falling debris (shock-vibration induced by impact).” This is the value assumed in computing the source term for the scenario.

Typical TRU waste containers are designed to withstand a 4-ft drop. Container mishandling from impact or drop is not likely to lead to an uncontrolled radioactive release. A *DR* of one-third is assumed to bound conditions in which drums are impacted and breached from a vehicle collision. A *LPF* of 1 is used for unmitigated analysis.

The source term is then:

$$\begin{aligned} ST &= 200\,PE - Ci \times \left(1 \times 10^{-3}\right) \times 0.1 \times \tfrac{1}{3} \times 1 \\ &= 6.7 \times 10^{-3}\,PE - Ci \end{aligned}$$

3.4.2.2.3 Consequence Analysis

This analysis was performed assuming the release occurs at B693. The dose consequence for unit of radioactivity released to the environment from MACCS2 is 22.1 rem/PE-Ci at B693 (WM/FS-WSF-0402). The radiation dose consequence to the MOI is then:

$$\begin{aligned} TEDE &= \left(6.7 \times 10^{-3}\,PE - Ci\right) \times 22.1\ {rem}/{PE - Ci} \\ &= 0.1\,rem \end{aligned}$$

For estimating the potential dose consequence to the co-located worker, the dose consequence result from MACCS2 at 100 m from the release is 40.6 rem/PE-Ci (WM/FS-WSF-0402). The radiation dose consequence to the co-located worker is then:

$$\begin{aligned} TEDE &= \left(6.7 \times 10^{-3}\,PE - Ci\right) \times 40.6\ {rem}/{PE - Ci} \\ &= 0.3\,rem \end{aligned}$$

The dose consequence from the postulated spill bounds that of a single or multiple drum spill in the building.

3.4.2.2.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public was 0.1 rem TEDE. This is well below, and is considered not to "challenge," the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.2.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated spill. Although the PrHA identified traffic controls as credited control for TRU waste spill scenarios, the accident analysis shows that the potential unmitigated consequences for these postulated spills is "low" for the public and the workers. The risk associated with these scenarios is also "low." Therefore, neither traffic controls nor training are required to mitigate the consequences of the postulated spills. However, the TSR captures traffic controls as a credited control to ensure that uncontrolled vehicles do not affect the DR used in the analysis.

Containers provide the means to packaging contaminated waste for transport and handling and provide defense in depth in postulated accidents. In addition, an array limit is assumed in the analysis. These are captured in the TSR to ensure that the conclusion of the analysis remains valid.

3.4.2.3 Fire Involving Stored TRU Waste Containers in Building

Based on the results of the hazard analysis in Section 3.3, a compartment fire involving TRU waste is identified as one of the scenarios to be analyzed in the accident analysis. Consequently, this section provides a bounding analysis of a compartment fire involving stored TRU waste containers to ensure that the postulated fire does not adversely impact the health and safety of the public and the workers. The fire is postulated to occur in the B693 Room 1014. B693 Room 1014 is the smallest compartment in the closest building to the fence line (130 m). The fire severity is the worst due to the small compartment size and the dose consequence results are bounding as discussed in Section 3.4.1.

The quantity of incidental flammable liquids present in the facility is substantially below the exempt quantities for the occupancy type of the facility. Although the quantities of transient flammable liquids and combustible materials are typically minimal in the Waste Storage Facilities, this scenario assumes a spill of 10 gal of incidental flammable liquid in the facility for conservatism. A spill and subsequent fire with 10-gal of flammable liquid bounds the dose consequences resulting from a compartment fire in the Waste Storage Facilities.

3.4.2.3.1 Scenario Development

TRU waste drums containing 50 PE-Ci each are assumed to be stored in B693. This analysis assumes that TRU waste drums are double-stacked on 4-ft × 4-ft pallets, and each pallet holds four drums. The postulated accident involves a spill of a transient flammable liquid brought into B693 for maintenance or other activities incidental to the storage of waste. For conservatism, the flammable liquid is assumed to be gasoline. Gasoline is a Class I flammable liquid with a low flashpoint and high vapor density. Due to its combustion characteristics, including a high heat of combustion and mass burning rate, the fire severity from a gasoline pool bounds that from other incidental flammable liquids brought into the facilities. An ignition source (such as a spark, electrical equipment short, or hot works) ignites the pool, resulting in a fire engulfing six TRU waste drums (based on a ratio of the area of the pool fire to the area occupied by the stored drums). An additional four TRU waste drums outside the fire exposed to the critical heat flux are also assumed impacted by the fire. The computed magnitude of the postulated fire is 4.1 MW (WM/FS-WSF-0404).

Based on the concurrent conditional probabilities of a spill of a transient flammable liquid, an available ignition source igniting the pool, and the resulting fire engulfing TRU waste containers all containing the maximum inventory, this accident scenario is considered “extremely unlikely.”

3.4.2.3.2 Source Term Analysis

One of the six drums engulfed in the fire is assumed to fail catastrophically (i.e., lid loss). While significant content expulsion from catastrophic drum failure caused by the engulfing fire was not observed in the large-scale drum fire test (WHC-SD-WM-TRP-246), it is conservatively assumed that 50% of the contaminated waste in the catastrophically failed drum is expelled by the engulfing fire. The remaining 50% is assumed to burn contained in the failed drum. For the ejected contents from the drum, the bounding ARF×RF of $1\times10^{-2}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "burning of unpackaged, loosely strewn cellulosic materials" is assumed. For the waste that burns in the drum, the bounding ARF×RF of $5\times10^{-4}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "contaminated combustible materials heated/burned in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, pails, drums)" is assumed.

The remaining five drums in the fire are assumed to fail by lid seal failure, resulting in contained burning of the contents with an ARF×RF of $5\times10^{-4}\times1$. An additional four TRU waste drums outside the fire exposed to the critical heat flux of 45 kW/m^2 or greater are conservatively also assumed to fail by lid seal failure resulting in contained burning. A DR of 0.6 is assumed for contained burning of waste in the nine drums that fail by lid seal failure (HC/AB-B696-0302).

Each drum is assumed to contain 50 PE-Ci. A LPF of unity is used for unmitigated analysis.

Although the effect of the postulated fire is not expected to be as severe on drums located away from the fire, the temperature effect was evaluated to ensure all aspects of the failure criteria are addressed. A dynamic fire analysis was performed in WM/FS-WSF-0404 to demonstrate that the peak smoke layer temperature in the compartment remains below 600ºC, the temperatures above which catastrophic failure (i.e., lid loss) was observed in the Westinghouse large-scale drum fire test.

B693 Room 1014 was modeled in the dynamic fire analysis since it has the smallest compartment size, and will therefore result in the worst fire severity as measured by the predicted smoke layer temperature. The predicted maximum temperature in the compartment was below 400ºC (WM/FS-WSF-0404). The Westinghouse large-scale drum fire test showed that the drum temperature at failure was greater than 600ºC and that flame impingement appeared to be the main cause for drum failure. Therefore, given the computed maximum temperature was less than 400ºC in the compartment, failure of drums not in the fire or exposed to the critical heat flux is not predicted.

The source term resulting from the postulated fire is, therefore, computed as follows (WM/FS-WSF-0404):

$$ST = \sum \begin{bmatrix} 1\,\text{drums} \times 50\,\text{PE}-\text{Ci}/\text{drum} \times 1\times10^{-2} \times 0.5 \times 1 \\ 1\,\text{drums} \times 50\,\text{PE}-\text{Ci}/\text{drum} \times 5\times10^{-4} \times 0.5 \times 1 \\ 9\,\text{drums} \times 50\,\text{PE}-\text{Ci}/\text{drum} \times 5\times10^{-4} \times 0.6 \times 1 \end{bmatrix} = 0.40\ \text{PE-Ci}$$

The source term developed for this scenario is independent of the TRU waste storage location, and will therefore be bounded by the dose consequence results from B693 as discussed in Section 3.4.1.

3.4.2.3.3 Consequence Analysis

Ten gallons of gasoline is assumed to spill and form a liquid pool with a resulting diameter of 1.5 m surrounding the drums. The computed peak heat release rate of the postulated fire is 4.1 MW resulting in a plume sensible heat of 1 MW (WM/FS-WSF-0404).

The potential dose consequence for unit of radioactivity released to the environment with a plume sensible heat of 1 MW is 6.6 rem/PE-Ci at the nearest site boundary from B693 (WM/FS-WSF-0404). The radiation dose consequence to the MOI is then:

$$\begin{aligned} TEDE &= 0.40 \text{ PE-Ci} \times 6.6 \ {}^{\text{rem}}\!/_{\text{PE-Ci}} \\ &= 2.6 \text{ rem} \end{aligned}$$

For estimating the potential dose consequence to the co-located worker, the worst-case dose consequence for unit of radioactivity released to the environment from WM/FS-WSF-0404 was selected. The potential dose consequence for unit of radioactivity released to the environment is 17.8 rem/PE-Ci at 100 m as shown in **Table 3-7**. The radiation dose consequence to the co-located worker is then:

$$\begin{aligned} TEDE &= 0.40 \text{ PE-Ci} \times 17.8 \ {}^{\text{rem}}\!/_{\text{PE-Ci}} \\ &= 7.1 \text{ rem} \end{aligned}$$

3.4.2.3.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public was 2.6 rem. This is well below, and is considered not to "challenge," the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.3.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated fire. However, programmatic provisions in the fire protection program provide defense in depth to mitigate the consequences of the postulated fire in the Waste Storage Facilities.

Containers provide the means to packaging contaminated waste for storage and provide defense in depth in postulated accidents. In addition, an inventory of 50 PE-Ci per container is assumed. TRU waste containers and inventory limits are captured in the TSR to ensure that the conclusion of the analysis remains valid.

3.4.2.4 Fire Involving Stored Tritium Contaminated Waste Containers in Building

Based on the results of the hazard analysis in Section 3.3, a fire inside a building storing tritium contaminated waste with subsequent release of radioactive material was identified as a unique scenario to be analyzed in the accident analysis. Consequently, this section provides a bounding analysis of a compartment fire involving stored tritium contaminated waste containers to ensure that the postulated fire does not adversely impact the health and safety of the public and the workers. B693 Room 1014 is the smallest compartment in the closest building to the fence line. The fire severity is the worst due to the small compartment size and the dose consequence results are bounding as discussed in Section 3.4.1.

The quantity of incidental flammable liquids present in the facility is substantially below the exempt quantities for the occupancy type of the facility. Although the quantities of transient flammable liquids and combustible materials are typically minimal in the Waste Storage Facilities, this scenario assumes a spill of 10 gal of incidental flammable liquid in the facility for conservatism. A spill and subsequent fire with 10-gal of flammable liquid bounds the dose consequences resulting from a compartment fire in the Waste Storage Facilities.

3.4.2.4.1 Scenario Development

It is assumed that tritium-contaminated waste containers with 2,000 Ci each of H^3 are stored in B693. Tritium contaminated waste, as well as all other low-level waste, can be stored in yard areas as close as 90 meters to the fence line. The fire scenario bounds the spill due to the form of the waste. The majority of the tritium Curies are as adsorbed water on molecular sieve or as metal tritides, both packaged in stainless steel traps. In both cases the heat of the fire is needed to release the tritium from the molecular sieve or the metal tritide. At ambient temperature, tritium release would be slow, based on exchange rates, desorption rates and surface reaction rates. The fire scenario in the building bounds an uncontained fire closer to the fence line, as the plume rise will be significantly greater in an outside fire. The containers are assumed to be either double-stacked on 4-ft×4-ft pallets with each pallet holding four drums, or triple stacked 4-ft×4-ft×7-ft boxes. The postulated accident involves a spill of a transient flammable liquid brought into a building storing tritium-contaminated waste for maintenance or other activities incidental to the storage of waste. For conservatism, the flammable liquid is assumed to be gasoline. Gasoline is a Class I flammable liquid with a low flashpoint and high vapor density. Due to its combustion characteristics, including a high heat of combustion and mass burning rate, the fire severity from a gasoline pool bounds that from other incidental flammable liquids brought into the facilities. An ignition source (such as a spark, electrical equipment short, or hot works) ignites the pool, resulting in a fire engulfing six tritium-contaminated waste containers (based on a ratio of the area of the pool fire to the area occupied by the stored containers). The computed magnitude of the postulated fire is 4.1 MW.

Based on the concurrent conditional probabilities of a spill of a transient flammable liquid, an available ignition source igniting the pool, and the resulting fire engulfing six tritium-contaminated waste containers all containing the maximum inventory, this accident scenario is considered “unlikely.”

All of the containers engulfed in the fire are assumed to fail catastrophically (i.e., rapid heating of all contents). The majority of high Curie tritium waste is in the form of tritiated water adsorbed on molecular sieve inside a stainless steel container or metal tritide inside a stainless steel container. It is conservatively assumed that the stainless steel container is damaged such that the contents become exposed to the fire in the six catastrophically failed containers. The fire impacts an additional four tritium contaminated waste containers outside the fire that are exposed to the critical heat flux. These containers are also assumed to fail such that the stainless steel container fails, and contaminated combustible material burns uncontained. Additional information about the dynamic fire analysis of the compartment fire is provided in Section 3.4.2.3.2.

3.4.2.4.2 Source Term Analysis

Each container is assumed to contain 2,000 Ci of tritium, split between 1,500 Ci in a stainless steel (SS) container (molecular sieve or metal tritide) and 500 Ci in contaminated combustibles (lab trash). Ten containers are assumed to fail catastrophically such that the SS container holding the molecular sieve or metal tritide breaks open. It is conservatively estimated that the SS container rapidly releases 100% of its contents as tritiated water (HTO or T_2O). For the ejected tritium contaminated combustibles from the drums, the bounding ARF×RF of 1.0 from Section 2.2 of DOE-HDBK-3010-94 for "vapors (condensable gases)" is assumed.

Each container is assumed to contain the maximum allowable radioactive material content of 2,000 Ci. A *LPF* of unity is used for unmitigated analysis.

The source term resulting from the postulated fire is computed as follows:

$$ST = \sum \begin{bmatrix} 10\,\text{container} \times 1{,}500\ \text{Ci}/\text{container} \times 1 \times 1 \times 1 \\ 10\,\text{containers} \times 500\ \text{Ci}/\text{container} \times 1 \times 1 \times 1 \times 1 \end{bmatrix} = 20{,}000\ \text{Ci}$$

3.4.2.4.3 Consequence Analysis

Ten gallons of gasoline is assumed to spill and form a liquid pool with a resulting diameter of 1.5 m surrounding the drums. The computed magnitude of the postulated fire is 4.1 MW resulting in a plume sensible heat of 1 MW when the fuel pool is ignited (WM/FS-WSF-0404).

This analysis was performed assuming the release occurs at B693 in order to bound the dose consequence results (see Section 3.4.1). The potential dose consequence for unit of radioactivity released to the fence line environment for a plume sensible heat of 1 MW is 8.25×10^{-6} rem/Ci (7.93×10^{-6} rem/Ci × 1.04 to adjust for ICRP 72) at the nearest site boundary from B693 (WM/FS-WSF-0401).

A correction is made for the fact that skin absorption increases the predicted inhalation dose by 50%. A factor of 1.5 times the dose factor is used. Adjusting for the skin absorption, the predicted dose consequence per unit release of tritium is:

$$TEDE/Ci = 8.25\times10^{-6}\ \text{rem}/\text{Ci} \times 1.5\ \text{dermal factor} = 1.24\times10^{-5}\ \text{rem}/\text{Ci}$$

The predicted radiation dose consequence to the MOI from tritium is then:

$$TEDE = 20{,}000\ \text{Ci} \times 1.24\times10^{-5}\ \text{rem}/\text{Ci} = 0.25\ \text{rem}$$

For estimating the potential dose consequence to the co-located worker, the worst-case dose consequence for unit of radioactivity released to the environment was utilized by assuming the release occurs at B625. The potential dose consequence for unit of radioactivity released to the co-located worker environment is 1.10×10^{-5} rem/Ci (1.06×10^{-5} rem/Ci × 1.04 to adjust for ICRP 72) at 100 m (WM/FS-WSF-0401). Adjusting for the skin absorption, the predicted dose consequence per unit release of tritium is:

$$TEDE/Ci = 1.10 \times 10^{-5}\ \mathrm{rem}/\mathrm{Ci} \times 1.5\ \mathrm{dermal\ factor} = 1.65 \times 10^{-5}\ \mathrm{rem}/\mathrm{Ci}$$

The predicted radiation dose consequence to the co-located worker from tritium is then:

$$TEDE = 20{,}000\ \mathrm{Ci} \times 1.65 \times 10^{-5}\ \mathrm{rem}/\mathrm{Ci} = 0.33\ \mathrm{rem}$$

3.4.2.4.4 Comparison to Guidelines

The conservative estimate of the tritium radiation dose consequences to the public was 0.25 rem. This is well below, and is considered not to "challenge," the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.4.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated fire. However, programmatic provisions in the fire protection program provide defense in depth to mitigate the consequences of the postulated large fire in the Waste Storage Facilities.

The inventory limit of 2,000 tritium Ci per container is assumed. This is captured in the TSR to ensure that the conclusion of the analysis remains valid.

3.4.2.5 A Large Fire involving Staged TRU Waste Containers in Yard

Before containers are transported into facilities for storage, they are typically staged in the yard. An individual container or multiple containers, for instance, a pallet of drums, can be transported at one time. Although the volume of vehicle traffic in the Waste Storage Facilities is small and the speed of the vehicles is limited both spatially and by the facility speed limit, there is a potential for a collision involving vehicles that are used to transport containers from other facilities.

Based on the results of the hazard analysis in Section 3.3, an array of drums involved in a vehicle accident with a fire involving the fuel from a truck is identified as one of the risk-dominant scenarios analyzed in the accident analysis. Consequently, this section provides a bounding analysis involving the staged drums to ensure that the postulated fire does not adversely impact the health and safety of the public and the workers.

A parametric analysis on the size of the fire, which determines the plume buoyancy, and on the distance to the site boundary was performed assuming conservative diffusion parameters using MACCS2 (HC/AB-B696-0203).

3.4.2.5.1 Scenario Development

An array of drums containing 200 PE-Ci is staged outside B693. The total inventory at risk is, thus, 200 PE-Ci in one array. A high-speed truck is postulated to impact the array of staged drums. Of the staged drums in the array, one third of the drums is assumed directly impacted by the truck and assumed to lose their structural integrity from the impact, even though each drum is capable of sustaining a 4-ft drop. The content of the impacted drums is assumed to be strewn in the yard. Further, ten gallons of diesel fuel in the tank leak to form a fuel pool with a diameter of 8.9 ft surrounding the drums and the scattered uncontained contaminated waste from the impacted drums. The fuel pool is subsequently ignited into a fire that engulfs the remaining drums and the scattered content of the impact-breached drums. The computed magnitude of the postulated fire was 8.9 MW lasting 140 seconds (HC/AB-B696-0203).

Based on the population of TRU waste containers and on-going activities in other facilities at LLNL, staging an array of containers totaling 200 PE-Ci is considered "anticipated" to "unlikely." A collision with a vehicle that is out of control resulting in significant damage to the containers is considered "unlikely." The concurrent conditional probabilities of a spill of fuel from the vehicle resulting in a large fuel pool, an available ignition source igniting the pool, and the resulting fire engulfing TRU waste containers all containing the maximum inventory, this accident scenario is considered "extremely unlikely."

3.4.2.5.2 Source Term Analysis

The array limit of 200 PE-Ci is used as the *MAR*. The bounding airborne respirable fraction (ARF×RF) of $5\times10^{-4}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "contaminated combustible materials heated/burned in packages with largely non-contaminated exterior surfaces (e.g., packaged in bags, compact piles, pails, drums)," is assumed in computing the source term for the waste that burns in the containers.

For the scattered content of breached drums, the bounding ARF×RF of $1\times10^{-2}\times1$ from Section 5.1 of DOE-HDBK-3010-94 for "uncontained cellulosics or largely cellulosic mixed waste" is assumed. The summary of assumptions in the analysis is as follows:

- The total inventory at risk in the array is 200 PE-Ci
- One third of the contaminated waste is expelled upon impact and burns on the ground (DR = 1/3)
- The two-thirds remaining in containers burns as packaged waste (DR = 2/3)

A *LPF* of 1 is used for unmitigated analysis. The source term is a combination of releases from uncontained burning and burning packaged waste, as follows:

$$ST = \sum \begin{bmatrix} 200\ \text{PE-Ci} \times (1\times10^{-2})\times1\times {}^{1}\!/_{3} \times 1 \\ 200\ \text{PE-Ci} \times (5\times10^{-4})\times1\times {}^{2}\!/_{3} \times 1 \end{bmatrix}$$
$$= 7.3\times10^{-1}\ \text{PE-Ci}$$

3.4.2.5.3 Consequence Analysis

Ten gallons of diesel fuel is assumed to spill from the truck fuel tank and form a fuel pool with a resulting diameter of 8.9 ft surrounding the drums and the scattered uncontained contaminated waste from the impacted drums. The computed magnitude of the postulated fire is 8.9 MW lasting 140 seconds (HC/AB-B696-0203) resulting in a plume sensible heat of 5 MW when the fuel pool is ignited.

This analysis was performed assuming the release occurs at B693. The potential dose consequence for unit of radioactivity released to the environment from MACCS2 for a plume sensible heat of 5 MW is 3.9 rem/PE-Ci at the nearest site boundary from B693 as shown in **Table 3-7**. The radiation dose consequence to the MOI is then:

$$\begin{aligned} TEDE &= 7.3\times10^{-1}\ \text{PE-Ci}\times3.9\ {}^{\text{rem}}\!/_{\text{PE-Ci}} \\ &= 2.8\ \text{rem} \end{aligned}$$

For estimating the potential dose consequence to the co-located worker, the worst-case dose consequence for unit of radioactivity released to the environment from HC/AB-B696-0203 was selected. The potential dose consequence for unit of radioactivity released to the environment is 11 rem/PE-Ci at 100 m as shown in **Table 3-7**. The radiation dose consequence to the co-located worker at 100 m is then:

$$\begin{aligned} TEDE &= 7.3\times10^{-1}\ \text{PE-Ci}\times11\ {}^{\text{rem}}\!/_{\text{PE-Ci}} \\ &= 8.0\ \text{rem} \end{aligned}$$

3.4.2.5.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public was 2.8 rem. This is well below, and is considered not to "challenge," the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.5.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated fire. However, programmatic provisions in the fire protection program and traffic controls to limit the potential for collisions provide defense in depth to mitigate the consequences of the postulated fire in the yard.

Containers provide the means to packaging contaminated waste for storage, transport, and handling and provide defense in depth in postulated accidents. In addition, the inventory limit of 200 PE-Ci per array staged in the yard is assumed. These are captured in the TSR to ensure that the conclusion of the analysis remains valid.

3.4.2.6 Airplane Crash with Fire In a TRU Waste Storage Building

Based on the results of the aircraft crash frequency analysis in Appendix B, the hazard analysis in Section 3.3 identified a general aviation aircraft crashing into B625 resulting in an uncontrolled radioactive release as one of the scenarios to be analyzed in the accident analysis. Consequently, this section provides a bounding analysis for the stored TRU waste containers to ensure that the postulated spill and ensuing fire does not adversely impact the health and safety of the public.

3.4.2.6.1 Scenario Development

A general aviation aircraft with a single reciprocating engine carrying a full tank of gasoline is postulated to crash into B625. The direct impact leads to penetration of the engine through the wall or the roof and crushes four TRU waste drums. The crash is postulated to be followed by an 18.4-MW fire involving gasoline spilled from the aircraft (HC/AB-B696-0302). This leads to additional failure of drums from the engulfing fire in the building.

This analysis assumes that TRU waste drums are double-stacked on 4-ft×4-ft pallets, each pallet holds four drums, and there is a 30-in separation between aisles of stacked drums.

3.4.2.6.2 Source Term Analysis

The other accident analyses in this DSA assume an individual TRU waste drum inventory of 50 PE-Ci. However, the specific administrative control stipulating that limit in sections 4.5.1.1 and 5.5.1 also states that drum loading and configuration shall be controlled to remain consistent with NEPA bounding consequence calculations. Both of these limits are initial conditions of analysis, and an airplane crash is the one scenario specifically analyzed and constrained by the NEPA bounding consequence calculation.

The material at risk for this scenario is derived from the bounding source term calculated in NEPA documentation. For B625, that source term is 1.4 PE-Ci (0.925 PE-Ci for B696R). The spectrum of potential drum loadings and configurations are therefore constrained so that the source term calculation does not exceed 1.4 PE-Ci.

The computational model used to assess against the 1.4 PE-Ci source term is defined in HC/AB-B696-0302. For the scenario postulating a fire ensuing the aircraft crash, a total of 25 drums are assumed engulfed in the postulated gasoline pool fire. Drums are assumed to fail through three mechanisms: direct impact from the aircraft engine, lid loss caused by the engulfing fire, and lid seal failure caused by the engulfing fire and exposure to a critical heat flux from the fire. The breakdown is as follows:

- Dimensions of a general aviation aircraft engine are approximately 36 in by 20 in. It is assumed that the initial direct impact leads to penetration through the structure of B625 and catastrophic failure of a total of four drums. The entire contents of these drums burn with an ARF×RF of 1×10^{-2}, the bounding ARF assigned in DOE-HDBK-3010-94 for combustion of unpackaged waste.

- Five of the drums engulfed in the fire are assumed to fail by lid loss. While significant content expulsion due to this failure mechanism was not observed in the large-scale drum fire test (WHC-SD-WM-TRP-246), it is conservatively assumed that 50% of the contaminated waste in these failed drums is expelled by the engulfing fire and burns with an ARF×RF of 1×10^{-2}. The remaining 50% is assumed to burn contained in the failed drums with an ARF×RF of 5×10^{-4}.

- The remaining 16 drums in the fire are assumed to fail by lid seal failure, resulting in contained burning of portions of their contents with an ARF×RF of 5×10^{-4}.

- The fire impacts an additional 20 TRU waste drums outside the fire that are exposed to the critical heat flux. These drums are also assumed to fail by lid seal failure and have subsequent burning of portions of their contents with an ARF×RF of 5×10^{-4}. A damage ratio of 0.6 is conservatively assumed for the drums that fail by lid seal failure.

The source term is computed as follows:

$$ST = \sum \begin{bmatrix} 4\text{ drums}\times 18\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 1\times10^{-2}\times 1\times 1 \\ 5\text{ drums}\times 18\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 1\times10^{-2}\times 0.5\times 1 \\ 5\text{ drums}\times 18\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 5\times10^{-4}\times 0.5\times 1 \\ 36\text{ drums}\times 18\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 5\times10^{-4}\times 0.6\times 1 \end{bmatrix} = 1.39\text{ PE - Ci}$$

Note that this reference calculation assumes all drums are equally loaded at 18 PE-Ci. However, individual drum loadings are variable based on the overall loading of any 45 contiguous drums (per the spacing defined in Section 3.4.2.6.1). As the individual loading of some drums goes down, the individual loading of other drums may go up. For example, if the loading of forty-one drums is only 1 PE-Ci each, the bounding four drums assumed to be impacted by the engine may be loaded to 33.5 PE-Ci each:

$$ST = \sum \begin{bmatrix} 4\text{ drums}\times 33.5\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 1\times10^{-2}\times 1\times 1 \\ 5\text{ drums}\times 1\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 1\times10^{-2}\times 0.5\times 1 \\ 5\text{ drums}\times 1\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 5\times10^{-4}\times 0.5\times 1 \\ 36\text{ drums}\times 1\ {}^{\text{PE - Ci}}\!/_{\text{drum}} \times 5\times10^{-4}\times 0.6\times 1 \end{bmatrix} = 1.38\text{ PE - Ci}$$

Per the above computational model, controlled positioning of drums may also be used to limit the number of high Curie content drums subject to the most severe accident stress. That remains consistent with the TSR specification that "drum loading and configuration shall be administratively controlled to remain consistent with the National Environmental Policy Act (NEPA) bounding consequences."

For a spill only scenario, the source term would be estimated assuming failure of four drums containing 50 PE-Ci each and utilizing the bounding impact ARF×RF of $1\times10^{-3}\times0.1$. The source term for the spill scenario is thus 0.02 PE-Ci, which is far below the bounding NEPA source term.

3.4.2.6.3 Consequence Analysis

The potential dose consequence for unit of radioactivity released to the environment for an 18.4-MW fire is 2.8 rem/PE-Ci at the nearest site boundary from B625 (WM/FS-WSF-0403). The contribution to the plume buoyancy from burning of the contaminated waste is minimal and is ignored for conservatism in this analysis. The radiation dose consequence to the MOI is then:

$$TEDE = 1.39\text{ PE Ci}\times 2.8\ {}^{\text{rem}}\!/_{\text{PE Ci}} = 3.9\text{ rem}$$

In estimating the potential dose consequence to the co-located worker, the maximum fire magnitude for unit of radioactivity released to the environment from HC/AB-B696-0203 was selected from **Table 3-8**. The potential dose consequence for unit of radioactivity released to the environment during a 9 MW fire at B625 is 11 rem/PE-Ci at 100 m. The radiation dose consequence to the co-located worker at 100 m is then:

$$\begin{aligned} TEDE &= 1.39 \text{ PE - Ci} \times 11 \ {}^{\text{rem}}\!/_{\text{PE - Ci}} \\ &= 15.3 \text{ rem} \end{aligned}$$

3.4.2.6.4 Comparison to Guidelines

The conservative estimate of the radiation dose consequences to the public was 3.9 rem. This is well below, and is considered not to "challenge," the evaluation guideline of 25 rem discussed in Appendix A of DOE-STD-3009-94 (DOE 2006).

3.4.2.6.5 Summary of Safety-Class SSCs and TSR Controls

No safety class structure, system, or component is identified from the analysis to prevent or to mitigate the consequences of the postulated air craft crash. No controls are considered necessary even if the consequences were to approach the Evaluation Guideline. This event is only marginally credible, physically cannot be mitigated if non-trivial quantities of TRU waste must be stored, and does not yield an overall dose risk that merits additional mitigation.

3.4.3 Beyond Design Basis Accidents

The evaluation of accidents beyond the design basis (BDB) are required in DOE-STD-3009-94 (DOE 2006) to provide a perspective of the residual risk associated with the operation of the facility. These postulated events serve as bases for cost-benefit considerations if consequences exceeding Evaluation Guidelines are identified in the beyond DBA range. However, such cost-benefit analysis would be performed outside the DSA with the concurrence of DOE. Three beyond design basis events are identified to provide a perspective of the residual risk associated with operation of the facility. This section provides a qualitative evaluation to obtain insight into the magnitude of consequences of beyond design basis accidents (i.e., provide perspective on potential facility vulnerabilities). These are beyond design basis wind, and a beyond design basis earthquake.

Operational beyond design basis accidents are not considered further in this section because the postulated events analyzed in Section 3.4.2 did not require any provisions to mitigate the consequences.

3.4.3.1 Winds

The consequences of BDB winds could include damage to the facility, typically short of facility collapse, resulting in direct damage to waste containers, and indirect damage to waste containers through the generation of missiles. TRU waste storage is limited to PC-2 buildings. Collapse of non-PC-2 facilities is evaluated in the PrHA. The consequences are bounded by the consequences for other scenarios identified in the PrHA. For operational accidents, analyses are performed using the 95th percentile of the distribution of doses to the MOI. Meteorological conditions for the beyond design basis wind would likely occur at conditions other than those used in the analysis. The difference in X/Q between, for example, Stability Class D with a wind speed of 72 mph (32 m/s)—the design basis wind speed, and that used in the analysis is approximately a factor of 10. In addition, the rubble covering the breached containers will reduce the ARF. Therefore, even if a pallet of TRU waste containers are breached by the beyond design basis wind, the consequences would be bounded by the operational spill scenarios and the Evaluation Guideline of 25 rem in Appendix A of DOE-STD-3009-94 (DOE 2006) is not challenged.

3.4.3.2 Earthquake

The frequency of a beyond design basis earthquake is "unlikely" with a return period greater than 1,000 years. The consequences of a beyond DBE could range from minor damage to the structure to the complete collapse of the facility. Damage to the facility, excluding complete collapse, could result in damage to some waste containers inside the building that could result in consequences greater than that estimated for the design basis earthquake. Thus, complete collapse of the facility could result in consequences that challenge the Evaluation Guide of 25 rem in Appendix A of DOE-STD-3009-94 (DOE 2006).

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CHAPTER 4
SAFETY STRUCTURES, SYSTEMS, AND COMPONENTS

4.1 Introduction

This chapter provides details on those structures, systems, and components (SSCs) that were classified as safety-significant as a result of the hazard analysis in Chapter 3. The structure and content of this chapter follow the outline provided in Chapter 4 of DOE-STD-3009-94, Change Notice 3 (DOE 2006). It establishes the adequacy of the controls by providing for each SSC, (1) its safety function(s) (as assumed in Chapter 3), (2) its functional requirements to support the safety function(s), (3) an evaluation with respect to its functional requirements, and (4) a brief description of the assumptions requiring control by TSR.

The following SSCs were identified in Chapter 3 as being the most significant to defense in depth and, hence, were designated safety-significant SSCs:

- TRU waste containers
- PC-2 structural capability of Waste Storage Facilities buildings storing TRU waste (i.e., B625 and B696R structures)
- B696S/B696R partition

These SSCs are passive features that serve as initial conditions for many events evaluated by the PrHA. Their safety functions contribute substantially to the prevention or mitigation of the bounding accident scenarios evaluated in the accident analysis, provide important defense-in-depth, or provide for worker safety in potentially life-threatening or disabling situations.

This chapter also provides the safety function(s), functional requirements, evaluation with respect to functional requirements, and a brief description of the assumptions requiring control by TSR for each of the Specific Administrative Controls (SACs).

4.2 Requirements

Based on the types of safety SSCs covered in this chapter, the following codes, standards, and DOE Orders are applicable to this chapter:

- DOE Order 420.1A, *Facility Safety* (§4.4 through 4.4.6 only) (DOE 2002a)
- DOE-STD-1020-94, Change Notice 1, *Natural Phenomena Hazard Design and Evaluation Criteria for Department of Energy Facilities* (DOE 1996)
- DOE-STD-1020-2002, *Natural Phenomena Hazard Design and Evaluation Criteria for Department of Energy Facilities* (DOE 2002b)
- DOE-STD-1186-2004, *Specific Administrative Controls* (DOE 2004)

- DOE-STD-3009-94, Change Notice 3, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis (DOE 2006)

4.3 Safety-Class Structures, Systems, and Components

No safety-class SSCs were identified in the accident analysis in Chapter 3 for the Waste Storage Facilities. The accident analysis results did not challenge the Evaluation Guideline.

4.4 Safety-Significant Structures, Systems, and Components

Safety-significant SSCs protect workers against potentially life-threatening or disabling conditions. The safety-significant SSC designation can also apply to SSCs that protect against large releases of radioactive material. This section discusses each of the safety-significant SSCs identified in Chapter 3 and describes their safety functions, functional requirements, SSC evaluation, and the TSR controls.

4.4.1 TRU Waste Containers

4.4.1.1 Safety Function

The TRU waste containers provide primary confinement for TRU waste material being handled or stored in the Waste Storage Facilities. The safety functions of TRU waste containers are to provide a barrier to significant releases and to mitigate releases in the event of mechanical impacts or thermal stresses.

TRU waste containers will be vented, except for TRU oversize boxes and LLW/TRU conversions (i.e., LLW containers that have been converted to TRU waste after assay). The containers are vented through carbon composite filter vents to preclude container pressurization caused by gas generation from radiolytic decomposition of waste material and other reactions and to prevent particulate matter from escaping.

4.4.1.2 System Description

Standard 55-gal drums, standard waste boxes (SWBs), TRU oversize boxes, and other steel containers meeting the definition of an approved TRU waste container (see Section 4.4.1.3) are used as packages for TRU waste in the Waste Storage Facilities. TRU oversize boxes are used primarily for large items that will not fit into standard containers.

The steel containers prevent loss of primary confinement for radioactive material being stored, staged or handled, thus preventing a significant release of radioactive material.

Carbon composite filter vents are installed in a threaded hole in most TRU waste containers (the exceptions are TRU oversize boxes and LLW/TRU conversions) to preclude container pressurization from gas generation and to prevent particulate matter from escaping. The filter itself serves a contamination control function and not a safety function for the purposes of this chapter.

4.4.1.3 Functional Requirements

Containers must provide a level of protection that supports the bases of the hazard and accident analyses. The functional requirements for approved TRU waste containers are as follows:

1. Containers must be vented (except for TRU oversize boxes and LLW/TRU conversions), and the vents must be designed to allow flammable gases that may be generated inside the waste container to be relieved.

2. Containers must meet the free drop test performance criteria for Type A packaging. Requirements for these containers are found in 49 CFR 173.465(c)(1) for the applicable package mass.

The following is a description of the approved TRU waste containers used to store TRU waste in the Waste Storage Facilities:

- DOT 17C, 17H or UN1A2 steel drums with vents (except for LLW/TRU conversions – see note).
- Standard waste boxes (SWBs) refers to oval-shaped steel containers with vents, roughly 3-ft H × 6-ft L × 4.5-ft W, designed for efficient loading into TRUPACT II Type B shipping containers.
- TRU oversize boxes refers to unvented steel containers, rectangular in shape. Built to contain large pieces of contaminated equipment, the dimensions of each TRU oversize box are unique. Heights vary from approximately 53-in to 101-in, widths vary from approximately 47-in to 70-in, and lengths vary from approximately 78-in to 138-in.
- Other steel containers with vents satisfying the free drop test performance criteria for Type A packaging (e.g., ten drum overpacks, 85-gal drums).

Note: LLW/TRU conversions are waste containers that have been assayed after acceptance and found to have greater than 100 nCi/g of alpha-emitting transuranic radionuclides (elements above uranium in the periodic table) with half-lives greater than 20 years, thereby meeting the definition of TRU waste. These containers have very low levels of TRU isotopes, on the order of 0.02 Ci total. These drums are steel containers that meet the free drop test Type A performance criteria [49 CFR 173.465(c)(1)], but are not required to be vented.

4.4.1.4 System Evaluation

The approved steel containers used to package TRU waste meet the above functional requirements. The performance criteria for these containers are that they protect the waste from mechanical stresses and the elements of weather and provide confinement for the waste. To ensure that containers meet these criteria, weekly inspections will be performed.

4.4.1.5 TSR Controls

The steel containers including vents (where applicable) are passive design features. As part of the TRU Waste Container Maintenance Program, weekly inspections of waste container integrity will be conducted.

4.4.2 PC-2 Structural Capability of B625 and B696R

The structural systems of B625 and B696R have been identified as safety significant SSCs based on the hazard analysis in Chapter 3.

4.4.2.1 Safety Function

The safety function of the structural systems of the Waste Storage Facilities buildings storing TRU waste is to not collapse in a PC-2 NPH event. Structural collapse could result in unacceptable damage to TRU waste containers.

4.4.2.2 System Description

The B625 and B696R structural systems consist of the following:

- foundations
- columns
- beams directly connected to the columns
- lateral bracing
- roof deck
- crane support/restraints (for B625)

No relevant interfaces, other than the structures mentioned above, would impact the building structures. Descriptions of these buildings are provided in Section 2.4.

4.4.2.3 Functional Requirements

The functional requirements necessary to fulfill the safety functions stated above are as follows:

- Maintain structural integrity (not collapse) during a seismic event up to a PC-2 earthquake.
- Maintain structural integrity (not collapse) during a PC-2 wind event.

4.4.2.4 System Evaluation

The performance criteria for the building structures are those for PC-2 designed and constructed buildings. B625 was built prior to the establishment of the DOE PC-2 criteria, but met the Uniform Building Code (UBC) at the time of construction. For this structure, calculations have been performed to confirm the structure meets the applicable PC-2 criteria. Every five years or less, the buildings will be assessed for their continued conformance with as-built structural design and for any conditions (e.g., damage or degradation) which may compromise their safety function.

4.4.2.5 TSR Controls

TRU waste storage structures are passive design features. A building inspection program is established, implemented, and maintained to ensure that the B625 and B696R structural systems meet their PC-2 requirements. This program includes inspections every five years or less by a qualified engineer (e.g., structural or civil) to verify that significant physical deterioration of or damage to the structures has not occurred.

4.4.3 B696S/B696R Partition

The partition between B696R and B696S has been identified as a safety-significant SSC as it serves to support segmentation between the Waste Storage Facilities and the B695 Segment.

4.4.3.1 Safety Function

The safety function of the partition between B696R and B696S is to reduce the likelihood of fire propagation. The partition between B696R and B696S serves to support segmentation. The partition wall is adequate to resist PC-2 seismic loading (WM-FS-696-0703).

4.4.3.2 System Description

The B696S/B696R partition is the wall assembly separating the low B696R and high bay B696S. The partition extends from true wall to true wall (inside of the exterior skin) in the north south direction and from the floor to the underside of the roof decks.

The cross-section of the partition between B696R and B696S consists of three layers of 5/8-in Type X sheet rock, on 4-in 20 gage metal studs, R-13 insulation, an approximately 5.75-in air gap, 4-in 20 gage metal studs, and three layers of 5/8-in Type X sheet rock.

4.4.3.3 Functional Requirements

The functional requirement necessary to fulfill the safety function stated above is to maintain a continuous vertical and horizontal construction assembly between B696R and B696S designed to limit the spread of heat and fire. Any modifications (e.g., penetrations) to the partition must be consistent with at least 2-hr fire-resistive rating.

4.4.3.4 System Evaluation

The partition continues to meet its safety function as long as the integrity of the continuous vertical and horizontal construction assembly remains uncompromised, even though minor damage to the partition may exist.

4.4.3.5 TSR Controls

The B696S/B696R partition is a passive design feature. The partition between B696R and B696S is inspected monthly and also inspected every five years or less to verify that significant physical deterioration or damage to the partition has not occurred.

4.5 Specific Administrative Controls (SACs)

SACs are those administrative controls that are selected to provide preventive and/or mitigative functions for specific potential accident scenarios, and which also have safety importance equivalent to engineered controls that would be classified as safety-class or safety-significant if the engineered controls were available and selected (DOE 2004).

4.5.1 TRU Waste Inventory Limits

4.5.1.1 Safety Function

A maximum inventory per container of 50 PE-Ci was used as the MAR for most hazard and accident analyses involving TRU waste. Thus, the container inventory limit is an assumed initial condition for most scenarios in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA. The SAC protects this assumption and ensures that the consequences determined in the hazard and accident analyses remain bounding.

The Waste Storage Facilities are also required to comply with National Environmental Policy Act (NEPA) analysis in the current LLNL Environmental Impact Statement (DOE 2005). The NEPA analysis establishes a bounding consequence based on overall facility inventory parameters. This SAC also requires that drum loading and configuration remain within the NEPA bounding consequence calculations. This limit was specifically used for all air craft crash with fire scenarios evaluated in the hazard and accident analysis.

4.5.1.2 SAC Description

This SAC is to control the amount of radioactive material in each approved TRU waste container in B696R and B625 at or below the amount analyzed in the DSA. This control is implemented through several diverse and redundant documents or procedures, namely, the Facility Safety Plan, the Radioactive Waste Acceptance Procedure, and the Storage & Disposal General Operating Procedures.

Independent of this nuclear facility safety basis analysis, the Waste Storage Facilities are also required to comply with NEPA analysis in the current LLNL Environmental Impact Statement (DOE 2005). This control is implemented through several diverse and redundant documents or procedures, namely, the Facility Safety Plan, the Radioactive Waste Acceptance Procedure, and the Storage & Disposal General Operating Procedures.

4.5.1.3 Functional Requirements

The SAC shall ensure that the radioactive material inventory for each approved TRU waste container in B696R or B625 is less than or equal to 50 PE-Ci. The radioactive material inventory limit requirement is met based on Acceptable Knowledge. Acceptable Knowledge characterization of TRU waste is based on an understanding of the materials and processes used to generate the waste, analytical data obtained from the process or waste stream, or both. Radionuclide quantification for individual radioactive waste containers will be performed. Written procedures will be followed to acquire, verify, and document Acceptable Knowledge.

Independent of the 50 PE-Ci limit, the Waste Storage Facilities are also required to comply with NEPA analysis in the current LLNL Environmental Impact Statement (DOE 2005).

4.5.1.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the tasks needed to assure each approved TRU waste container is at or below the established inventory limits for B696R and B625 prior to the storage of the TRU waste container in B696R or B625 as assumed in the safety basis.

4.5.1.5 Controls (TSRs)

For each approved TRU waste container in B696R or B625, the amount of radioactive material shall be no greater than 50 PE-Ci based on Acceptable Knowledge. Drum loading and configuration, shall be administratively controlled to remain consistent with the NEPA bounding consequence calculations.

4.5.2 Fissile Material Container Limit

4.5.2.1 Safety Function

200 Pu-239 FGE was identified as an assumed condition in the hazard analysis criticality event scenarios. This control serves to limit the quantity of fissile material in each TRU waste container. The material form, packaging and segregation required by the Criticality Safety Program preclude the possibility of an inadvertent criticality for 200 grams of Pu-239. CSM 1344 (LLNL 2003), "CRITICALITY SAFETY EVALUATION On the Use of 200-gram Pu Drum Mass Limit for RHWM Waste Storage Operations," provides the technical basis for the 200 Pu-239 FGE.

4.5.2.2 SAC Description

This SAC is to control the amount of fissile material in each waste container for criticality concern. This control is implemented through several diverse and redundant methods, namely, the Facility Safety Plan, the Radioactive Waste Acceptance Procedure, and the Storage & Disposal General Operating Procedures to ensure that the amount of fissile material in each waste container is no greater than 200 Pu-239 FGE. During waste acceptance, RHWM personnel verify that waste containers meet the established limit in accordance with the established procedures.

4.5.2.3 Functional Requirements

The SAC shall ensure that the fissile material in each container is less than or equal to 200 Pu-239 FGE. The fissile material limit requirement for each waste container is met based on Acceptable Knowledge. Acceptable knowledge is based on an understanding of the materials and processes used to generate the waste, or analytical data obtained from the process or waste stream or both. Radionuclide quantification for individual radioactive waste containers will be performed. Written procedures will be followed to acquire, verify, and document Acceptable Knowledge.

4.5.2.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to assure each waste container is at or below the fissile material inventory limit for each waste container prior to storage of the container as assumed in the safety basis.

4.5.2.5 Controls (TSRs)

For each container, the fissile material inventory shall be no greater than 200 Pu-239 FGE.

4.5.43 Tritium Container Limit

4.5.3.1 Safety Function

A maximum inventory per container of 2,000 Ci of tritium was used as the MAR for the hazard and accident analyses. Thus, the container inventory limit for tritium is an assumed condition in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA, and serves to limit the quantity of tritium that can be impacted in accident scenarios. The SAC protects this assumption and ensures that the consequences determined in the hazard and accident analyses remain bounding.

4.5.3.2 SAC Description

This SAC is to control the amount of tritium in each container at or below the amount analyzed in the DSA. This control is implemented through two diverse and redundant methods, namely, the Facility Safety Plan and the Radioactive Waste Acceptance Procedure to ensure that the amount of tritium inventory in each container is no greater than 2,000 Ci.

4.5.3.3 Functional Requirements

The SAC shall ensure that the tritium inventory for each waste container is less than or equal to 2,000 Ci. The tritium inventory limit requirement is met based on Acceptable Knowledge. Acceptable knowledge characterization of radioactive waste is based on an understanding of the materials and processes used to generate the waste, or analytical data obtained from the process or waste stream or both. Radionuclide quantification for individual radioactive waste containers will be performed. Written procedures will be followed to acquire, verify, and document Acceptable Knowledge.

4.5.3.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to assure each waste container is at or below the tritium material inventory limit prior to storage of the container as assumed in the safety basis.

4.5.3.5 Controls (TSRs)

The amount of tritium in a waste container shall be no greater than 2,000 Ci based on Acceptable Knowledge.

4.5.4 TRU Waste Staging Limits

4.5.4.1 Safety Function

The MAR of 200 PE-Ci was used in the hazard and accident analyses as the maximum inventory for an impacted array of staged waste containers in the yard. Thus, the outdoor array limit is an assumed condition in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA, and serves to limit the quantity of radioactive material that can be impacted in accident scenarios involving staged waste.

Staging time limitations for TRU waste containers minimizes the potential for a vehicle collision with staged TRU waste.

By separating arrays 10 feet (HC/AB B696 0301), drums in one array will not fail from exposure to the critical radiant heat flux of 45 kW/m2 (identified in WHC-SD-WM-TRP-246, 1995) from a fire in another array.

4.5.4.2 SAC Description

This SAC is to control the amount of radioactive material and identify the separation requirement for each array of TRU waste containers staged in the yard for up to 36 hours. This control is implemented through several diverse and redundant methods, namely, the Facility Safety Plan, the Storage & Disposal General Operating Procedures, and TSR Daily Inspection Logs to ensure that the inventory for each array of staged TRU waste containers in the yard is no greater than 200 PE-Ci, is separated from other TRU waste container arrays by no less than 10 feet, and is staged for no more than 36 hours.

4.5.4.3 Functional Requirements

The SAC shall ensure that TRU waste containers staged in the yard are:

- In arrays with no greater than 200 PE-Ci each
- Separated from other staged TRU waste container arrays by no less than 10 feet
- Staged for no more than 36 hours

Written procedures will be followed to provide instructions for tasks to be performed.

4.5.4.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to meet the staging array inventory limit, the staging array separation requirement, and the 36 hour staging time limit as assumed in the safety basis.

The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that the inventory for each array of TRU waste containers to be staged in the yard is no greater than 200 PE-Ci, will be separated from other TRU waste container arrays by no less than 10 feet, and is staged for no more than 36 hours. There are no time restraints associated with performing the required operations other than ensuring the 36 hour limit is met.

4.5.4.5 Controls (TSRs)

TRU waste may be staged outside the building up to 36 hours and shall be limited to arrays with a maximum inventory of 200 PE-Ci per array. Any one array of staged TRU waste shall be separated from other arrays by no less than 10 feet.

4.5.5 Authorized TRU Waste Storage Locations

4.5.5.1 Safety Function

The hazard analysis assumes that TRU waste is stored in building structures meeting PC-2 requirements. In addition, it assumes that TRU waste is not stored coincident with flammable liquid storage areas. This control serves to limit the locations that are authorized to store TRU waste to protect these assumptions.

4.5.5.2 SAC Description

This SAC is to limit the allowable locations to store TRU waste consistent with the assumptions of the Waste Storage Facilities DSA. This control is implemented through two diverse and redundant methods, namely, the Facility Safety Plan and the Storage & Disposal General Operating Procedures to ensure that TRU waste storage is limited to B696R and B625.

4.5.5.3 Functional Requirements

This SAC shall ensure that TRU waste is only stored in B696R and B625.

4.5.5.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that TRU waste storage is limited to B696R and B625 as described in the safety basis.

The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that TRU waste containers are only stored in B696R or B625; TRU waste containers may be staged throughout the Waste Storage Facilities yard areas consistent with the staging limits described in Sections 4.5.5 and 4.5.10. There are no time restraints associated with performing the required operations.

4.5.5.5 Controls (TSRs)

TRU waste storage shall be limited to B696R and B625.

4.5.6 Storage in TRU Waste Containers

4.5.6.1 Safety Function

Containers provide a confinement function limiting worker exposures and radioactive waste vulnerability in accident scenarios involving containerized TRU waste. Accordingly, TRU waste containers meeting specified criteria were an assumed condition in the hazard and accident analyses for scenarios involving TRU waste. TRU waste containers typically have carbon composite filter vents, which minimize the potential for buildup of gases.

4.5.6.2 SAC Description

This SAC is to ensure that all TRU waste is stored in approved TRU waste containers. TRU waste containers are a safety-significant SSC and are described in Section 4.4.1. This control is implemented through three diverse and redundant methods, namely, the Facility Safety Plan, Radioactive Waste Acceptance procedure, and the Storage & Disposal General Operating Procedures to ensure that the TRU waste is stored in an approved TRU waste container.

4.5.6.3 Functional Requirements

The SAC shall ensure that all TRU waste accepted into the RHWM nuclear facilities is in approved TRU waste containers, as described in Section 4.4.1. Written procedures will be followed to provide instructions for tasks to be performed.

4.5.6.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that TRU waste is stored in approved TRU waste containers as assumed in the safety basis.

Prior to acceptance, Radiological Characterization Analysts (RCAs) review all waste packages to ensure they meet the RHWM waste acceptance criteria. As part of this process, the RCAs verify that all TRU waste is packaged in approved TRU waste containers.

4.5.6.5 Controls (TSRs)

All TRU waste shall be stored in approved TRU waste containers.

4.5.7 TRU Waste Container Stacking Limits

4.5.7.1 Safety Function

Stacking TRU waste containers no more than two high was identified in seismic hazard analysis scenarios as a credited control. Containers meeting the free drop test DOT Type A packaging performance criteria [49 CFR 173.465(c)(1)] are used to store TRU waste. These containers are designed to survive at least a 4-ft drop consistent with the performance criteria for Type A packaging. This SAC serves to ensure that stacked containers will not fall greater than 4-ft in the event of an earthquake, and hence will not breach. Ten drum overpacks are approximately 6-ft in height, and therefore, are not stacked.

4.5.7.2 SAC Description

This SAC is to control stacking of approved TRU waste containers, so the assumptions made in the hazard analysis are protected. This control is implemented through several diverse and redundant methods, namely, the Facility Safety Plan, the Storage & Disposal General Operating Procedures, and Weekly Inspection Logs to ensure that stacking of approved TRU waste containers is limited consistent with the assumptions made in the safety basis. Control of the stacking is administrative in nature. During TRU waste container storage and handling activities, RHWM operations personnel ensure that TRU waste containers are not stacked more than 2 high and that TRU waste containers exceeding a nominal height of 4-ft (e.g., ten drum overpacks) are not stacked.

4.5.7.3 Functional Requirements

The SAC shall ensure that approved TRU waste containers are stacked no more than two high and that TRU waste containers exceeding a nominal height of 4-ft are not stacked, consistent with the controls identified in the hazard analysis. Written procedures will be followed to provide instructions for tasks to be performed.

4.5.7.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that stacking of approved TRU waste containers is within the assumptions made in the safety basis. The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that

TRU waste containers are not stacked more than two high and that TRU waste containers exceeding a nominal height of 4-ft are not stacked.

4.5.7.5 Controls (TSRs)

Approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-ft shall not be stacked.

4.5.8 Closed TRU Waste Containers

4.5.8.1 Safety Function

The hazard and accident analyses assume that TRU waste in the Waste Storage Facilities is maintained in closed containers. The assumed condition in the Waste Storage Facilities DSA for all TRU waste scenarios is that the waste is confined in approved TRU waste containers. Opening TRU waste containers is outside the scope of work at the Waste Storage Facilities.

4.5.8.2 SAC Description

This SAC is to maintain approved TRU waste containers in a closed condition, so the assumptions made in the analyses are protected. This control is implemented through two diverse and redundant methods, namely, the Facility Safety Plan and the Storage & Disposal General Operating Procedures to ensure that approved TRU waste containers are not opened in the Waste Storage Facilities.

4.5.8.3 Functional Requirements

The SAC shall ensure that all TRU waste in the Waste Storage Facilities is maintained in closed containers. Written procedures will be followed to provide instructions for tasks to be performed.

4.5.8.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will ensure that TRU waste containers are not opened in the Waste Storage Facilities.

4.5.8.5 Controls (TSRs)

Approved TRU waste containers shall not be opened in the Waste Storage Facilities.

4.5.9 TRU Waste Container Staging Locations

4.5.9.1 Safety Function

The accident analysis in Section 3.4 of the Waste Storage Facilities DSA assumed that releases of TRU waste occurred no less than 130 m from the site boundary (Greenville Road fence line). Thus, this distance is an assumed condition in the accident analysis in Section 3.4 of the Waste Storage Facilities DSA, and serves to limit the consequences to the off-site public.

4.5.9.2 SAC Description

This SAC is to control the proximity of TRU waste containers to the Greenville Road site boundary to no less than 130 m, so the assumptions made in the accident analysis are protected. This control is implemented through two diverse and redundant methods, namely, the Facility Safety Plan and the

Storage & Disposal General Operating Procedures. During TRU waste container staging, RHWM operations personnel ensure that TRU waste containers are not staged less than 130 m from the Greenville Road fence line (i.e., east of the B693 structure).

4.5.9.3 Functional Requirements

The SAC shall ensure that TRU waste containers are not staged less than 130 m from the Greenville Road fence line (east of the B693 structure). This is an assumed condition in the accident analysis in Section 3.4 of the Waste Storage Facilities DSA. Written procedures will be followed to provide instructions for tasks to be performed.

4.5.9.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that staging of approved TRU waste containers is within the assumptions made in the safety basis.

The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that TRU waste containers staged in the DWTF yard are not staged east of the B693 structure.

4.5.9.5 Controls (TSRs)

Approved TRU waste containers shall not be staged less than 130 m from the Greenville Road fence line (east of the B693 structure).

4.5.10 Use of Metal Containers and Pallets for Waste in TRU Waste Storage Areas

4.5.10.1 Safety Function

The use of metal containers and pallets for waste stored in TRU waste storage areas limits the potential for fire initiation and propagation during operational or other events in TRU waste storage areas by limiting available combustibles. This is a credited control for waste handling and natural phenomena hazard scenarios in the hazard analysis. This control serves to ensure that low-level, hazardous, and other wastes that can be stored coincident with TRU waste are in non-combustible packaging and on non-combustible pallets.

4.5.10.2 SAC Description

This SAC is to limit the amount of combustible material in TRU waste storage areas by requiring the use of metal containers and pallets for waste stored in these areas. RHWM procedures limit storage in TRU waste storage areas (B696R and B625) to waste in metal containers and on metal pallets. Low-level, hazardous, and other wastes may be stored in the same location as TRU waste; this control ensures that these wastes are in metal containers to limit the likelihood of fire propagation and initiation from an available ignition source. This control also ensures that TRU and other wastes are on metal pallets to limit the likelihood of fire propagation. This control is implemented through two diverse and redundant methods, namely, the Facility Safety Plan and the Storage & Disposal General Operating Procedures. Consistent with these procedures, RHWM personnel ensure that only waste in metal containers and on metal pallets are stored in TRU waste storage areas.

4.5.10.3 Functional Requirements

The SAC shall ensure that only waste in metal containers and on metal pallets is stored in TRU waste storage areas (B696R and B625). Written procedures will be followed to provide instructions for tasks to be performed.

4.5.10.4 SAC Evaluation

The performance criterion imposed on this SAC is that RHWM operations personnel will complete the procedural tasks needed to ensure that only waste in metal containers and on metal pallets is stored in TRU waste storage areas.

The duties to be performed by RHWM operations personnel to successfully perform the SAC are very simple. The RHWM operations personnel must simply verify that waste containers stored in TRU waste storage areas are metal and that these containers are on metal pallets.

4.5.10.5 Controls (TSRs)

Only waste in metal containers and on metal pallets shall be allowed in TRU waste storage areas.

4.6 References

DOE (1996), *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-94, Change Notice 1, U.S. Department of Energy, Washington, DC, June 1996.

DOE (1997), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, DOE-STD-1027-92, Change Notice 1, U.S. Department of Energy, Washington, DC, September 1997.

DOE (2002a), *Facility Safety*. DOE Order 420.1A, U.S. Department of Energy, Washington DC, May 2002.

DOE (2002b), *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, DOE-STD-1020-2002, U.S. Department of Energy, Washington, DC, January 2002.

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. DOE-STD-3009-94, Change Notice 3. U.S. Department of Energy, Washington, DC, March 2006.

HC/AB-B696-0301, “Fire involving flammable liquids and separation distances,” Joong M. Yang, Lawrence Livermore National Laboratory, Livermore, CA, March 2003.

LLNL (2003), CSM 1344, “CRITICALITY SAFETY EVALUATION On the Use of 200-gram Pu Drum Mass Limit for RHWM Waste Storage Operations,” Lawrence Livermore National Laboratory, August 2003.

WHC-SD-WM-TRP-246, “Solid Waste Drum Array Fire Performance,” Rev. 0, Westinghouse Hanford Company, 1995.

WM-FS-969-0703 “Evaluation of an Existing Partition Wall in Building 696, Room 1009,” Derek Westphal, Lawrence Livermore National Laboratory, Livermore, CA, January 9, 2008.

CHAPTER 5
DERIVATION OF TECHNICAL SAFETY REQUIREMENTS

5.1 Introduction

The technical safety requirements (TSRs) were developed to ensure adequate protection for the off-site and on-site populations in the event of an uncontrolled release of radioactive material. Based on the information in DOE-STD-1027-92, Change Notice 1 (DOE 1997), it was determined that the Waste Storage Facilities are Hazard Category 2 non-reactor nuclear facilities. The TSRs consist primarily of inventory limits and controls preserving the underlying assumptions in the hazard and accident analyses. Further, appropriate commitments to safety programs are presented in the administrative controls sections of this chapter.

5.2 Requirements

A list of key requirements is provided below. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

- 10 CFR 830, *Nuclear Safety Management*
- DOE-STD-3009-94, Change Notice 3, *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports* (DOE 2006)

5.3 TSR Coverage

This section lists the features identified in Chapters 3 and 4 that are needed to do the following:

- provide important defense in depth;
- assure worker safety; and
- maintain consequences of facility operations at levels below the Evaluation Guideline.

The unmitigated estimate of the radiation dose consequence to the public from the bounding design basis accident from Section 3.4.2 is less than 3 rem TEDE, which is well below, and does not “challenge,” the Evaluation Guideline. No safety-class SSCs were identified based on the analyses, and the TSR controls discussed in the following sections provide important defense in depth and worker safety.

5.3.1 Important Defense in Depth requiring TSR coverage

Shown in **Table 5-1** are the individual design features and their associated assumptions that require coverage in the Waste Storage Facilities TSRs. **Table 5-2** shows the individual control features and their associated assumptions that require coverage in the Waste Storage Facilities TSRs. The details of these controls are discussed in Section 5.5.

5.3.2 Worker Safety

The design features and controls in **Table 5-1** and **Table 5-2** provide for worker safety. Additionally, the following programs provide for worker safety.

1. Radiation Protection Program
2. Hazardous Material Protection Program
3. In-service Inspection & Test and Maintenance Programs
4. Fire Protection Program
5. Training Program
6. Emergency Preparedness Program
7. Configuration Management Program

Additional details on these programs are provided in Section 5.5.

5.3.3 Safety-Class SSCs

No safety-class SSCs were identified in the hazard and accident analyses.

Table 5-1. Design Features Requiring TSR Coverage

Feature	Assumption
Storage of TRU waste in approved TRU waste containers	Reduces frequency of common spill and fire accidents during normal waste-container operations and reduces probability of breaching of containers stored on either the first or second level during a DBE or DBW. Vents reduce frequency of buildup of flammable gases from radiolysis. This subsequently reduces the probability of a deflagration.
B625 and B696R building structural systems	The B625 and B696R structural systems will not collapse in PC-2 earthquake and wind events.
B696S/B696R partition	The partition separates B696R from B696S for segmentation purposes.

Table 5-2. Control Features and Associated Assumptions

Feature	Assumption
A limit of 50 PE-Ci of radioactive material per container, with the exception of tritium, which is limited to 2,000 Ci per container. Inventory configuration and loading is administratively controlled consistent with the NEPA limits.	Limits the amount of radioactive material that can be impacted by postulated accidents involving TRU waste or LLW containing tritium in the Waste Storage Facilities. Maintains consistency with NEPA radioactive inventory configuration and loading limits.
The fissile material inventory per container is limited to 200 Pu-239 fissile gram equivalents (FGE).	Limits the amount of fissile material to preclude an inadvertent criticality.
A maximum limit of 200 PE-Ci of radioactive material in an array of containers staged in the yard, and limited to 36 hours with a minimum separation of 10 ft between arrays.	Limits the amount of radioactive material that can be impacted by accidents in the yard.
A limit of two stacking levels for TRU waste containers. TRU waste containers exceeding nominal height of 4-ft will not be stacked.	Minimizes the potential for drum failure from toppling during a DBE. TRU waste containers are designed to withstand a 4-ft drop. Ten drum overpacks are approximately 6-ft in height.
TRU waste containers will not be opened.	Ensures waste is confined in closed metal containers. Opening TRU waste containers is outside the scope of work at the Waste Storage Facilities.
TRU waste containers will not be staged less than 130 m from the Greenville Road fence line (i.e., east of B693 structure).	Minimum distance to fence line assumed for postulated TRU waste accidents involving staged waste in the hazard and accident analyses.
TRU waste storage limited to B696R and B625.	Limits the locations that are authorized for TRU waste storage.
Traffic Control Program	Protection from vehicular traffic is judged to provide significant benefit in reducing the frequency of events impacting staged containers in the Waste Storage Facilities yards.
Criticality Safety Program	Controls operations and storage of radioactive waste such that an inadvertent criticality event is precluded.
Single Container Inventory Limit Program (SCIL) for chemical waste (implemented as part of the Hazardous Material Protection Program)	Limits the amount of chemical waste that can be impacted by postulated accidents involving hazardous, mixed, or combined waste containers in the Waste Storage Facilities.
In-service Inspection & Test (ISIT) Program	The building inspection program portion of the ISIT Program ensures that the B625 and B696R PC-2 building structural systems maintain structural integrity during PC-2 events and that the partition between B696R and B696S is maintained consistent with the functional requirements provided in Section 4.4.3.3. The TRU waste container maintenance program portion of the ISIT Program preserves TRU waste container integrity and reduces the probability of buildup of flammable gases from radiolysis.
Only waste in metal containers and on metal pallets allowed in TRU waste storage areas. Additional combustible loading controls to minimize fire-loading (implemented as part of the Fire Protection Program).	Limits the potential for fire initiation and propagation during operational or other events in TRU waste storage areas to mitigate consequences from fires involving TRU waste.
Keep Clear areas (implemented as part of the Fire Protection Program)	To maintain segmentation boundaries and protect the assumption that an accident outside the segment will not impact the TRU waste within the segment.
Certified crane operators (implemented as part of the Training Program)	Reduces the likelihood of crane accidents occurring as a result of operator error.

5.3.4 Safety-Significant SSCs

Based on the analysis in Chapter 3, the following SSCs have been designated as safety significant:

- TRU waste containers
- B625 and B696R structural systems
- B696S/B696R partition

Chapter 4 contains a discussion of the safety function for each of these safety significant SSCs. These SSCs are passive design features.

5.4 Derivation of Facility Modes

Facility modes are not required since there are no Limiting Conditions of Operation.

5.5 TSR Derivation

Based on the hazard and accident analyses, there are no Safety Limits, Limiting Control Settings, Limiting Conditions of Operation, or Surveillance Requirements. TSR coverage will be required for design features and ACs that provide defense-in-depth. The design features are approved TRU waste containers; the PC-2 B625 and B696R building structural systems; and the B696S/B696R partition. Programmatic ACs are discussed in further detail in the programmatic chapters. Specific ACs are described below in Sections 5.5.1 and 5.5.2. There will be no sections that further describe Safety Limits, Limiting Control Settings, Limiting Conditions of Operation, or Surveillance Requirements.

5.5.1 Specific Inventory Limits

1. For each approved TRU waste container in B696R or B625, the amount of radioactive material shall be no greater than 50 PE-Ci based on Acceptable Knowledge. Drum loading and configuration shall be administratively controlled to remain consistent with the National Environmental Policy Act (NEPA) bounding consequence calculations.

   Safety Function: A maximum inventory per container of 50 PE-Ci was used as the MAR for most hazard and accident analyses involving TRU waste. Thus, the container inventory limit is an assumed initial condition in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA. The SAC protects this assumption and ensures that the consequences determined in the hazard and accident analyses remain bounding.

   Waste Storage Facilities facilities are also required to comply with NEPA analysis in the current LLNL Environmental Impact Statement (EIS). The NEPA analysis establishes a bounding consequence based on overall facility inventory parameters. This SAC also requires that drum loading and configuration, remain within the NEPA bounding consequence calculations. This limit was specifically used for all air craft crash scenarios with fire evaluated in the hazard and accident analysis.

   Basis: This SAC limits the amount of radioactive material that can be impacted by postulated accidents involving TRU waste in the Waste Storage Facilities and maintains consistency with the NEPA bounding consequence calculations.

2. For each container, the fissile material inventory shall be no greater than 200 Pu-239 FGE.

Safety Function: 200 Pu-239 FGE was identified as an assumed condition in the hazard analysis criticality event scenarios. This control serves to limit the quantity of fissile material in each TRU waste container. The material form, packaging and segregation required by the Criticality Safety Program preclude the possibility of an inadvertent criticality for 200 grams of Pu-239. CSM 1344 (LLNL 2003), "CRITICALITY SAFETY EVALUATION On the Use of 200-gram Pu Drum Mass Limit for RHWM Waste Storage Operations," provides the technical basis for the 200 Pu-239 FGE.

Basis: This SAC limits the amount of fissile material to preclude an inadvertent criticality.

3. The amount of tritium in a waste container shall be no greater than 2,000 Ci based on Acceptable Knowledge.

   Safety Function: A maximum inventory per container of 2,000 Ci of tritium was used as the MAR for the hazard and accident analyses. Thus, the container inventory limit for tritium is an assumed condition in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA, and serves to limit the quantity of tritium that can be impacted in accident scenarios. The SAC protects this assumption and ensures that the consequences determined in the hazard and accident analyses remain bounding.

   Basis: This SAC limits the amount of radioactive material that can be impacted by postulated accidents involving LLW containing tritium in the Waste Storage Facilities.

4. TRU waste may be staged outside the building up to 36 hours and shall be limited to arrays with a maximum inventory of 200 PE-Ci per array. Any one array of staged TRU waste shall be separated from other arrays by no less than 10 feet.

   Safety Function: The MAR of 200 PE-Ci was used in the hazard and accident analyses as the maximum inventory for an impacted array of staged waste containers in the yard. Thus, the outdoor array limit is an assumed condition in the hazard and accident analyses in Sections 3.3 and 3.4 of the Waste Storage Facilities DSA, and serves to limit the quantity of radioactive material that can be impacted in accident scenarios involving staged waste.

   Staging time limitations for TRU waste containers minimizes the potential for a vehicle collision with staged TRU waste.

   By separating arrays 10 feet (HC/AB B696 0301), drums in one array will not fail from exposure to the critical radiant heat flux of 45 kW/m2 (identified in WHC-SD-WM-TRP-246, 1995) from a fire in another array.

   Basis: This SAC limits the amount of radioactive material that can be impacted by accidents in the yard.

5.5.2 Specific Container Handling and Storage Provisions

The following requirements are specified as individual controls:

1. TRU waste storage shall be limited to B696R and B625.

   Safety Function: The hazard analysis assumes that TRU waste is stored in building structures meeting PC-2 requirements. In addition, it assumes that TRU waste is not stored coincident with flammable liquid storage areas. This control serves to limit the locations that are authorized to store TRU waste to protect these assumptions.

Basis: This SAC limits the locations that are authorized for TRU waste storage.

2. All TRU waste shall be stored in approved TRU waste containers (i.e., steel containers that satisfy the criteria provided in Section 4.4.1).

   Safety Function: Containers provide a confinement function limiting worker exposures and radioactive waste vulnerability in accident scenarios involving containerized TRU waste. Accordingly, TRU waste containers meeting specified criteria were an assumed condition in the hazard and accident analyses for scenarios involving TRU waste. TRU waste containers typically have vents, which minimize the potential for buildup of gases.

   Basis: This SAC reduces the frequency of common spill and fire accidents during normal waste-container operations and reduces the probability of breaching of containers stored on either the first or second level during a natural phenomena event. Vents reduce the frequency of buildup of flammable gases from radiolysis which reduces the probability of a deflagration.

3. Approved TRU waste containers shall not be stacked more than two levels high. Approved TRU waste containers exceeding a nominal height of 4-ft shall not be stacked.

   Safety Function: Stacking TRU waste containers no more than two high was identified in seismic hazard analysis scenarios as a credited control. Containers meeting the free drop test DOT Type A packaging performance criteria [49 CFR 173.465(c)(1)] are used to store TRU waste. These containers are designed to survive at least a 4-ft drop consistent with the performance criteria for Type A packaging. This SAC serves to ensure that stacked containers will not fall greater than 4-ft in the event of an earthquake, and hence will not breach. Ten drum overpacks are approximately 6-ft in height, and therefore, are not stacked.

   Basis: This SAC minimizes the potential for drum failure from toppling since TRU waste containers are designed to withstand a 4-ft drop.

4. Approved TRU waste containers shall not be opened in the Waste Storage Facilities.

   Safety Function: The hazard and accident analyses assume that TRU waste in the Waste Storage Facilities is maintained in closed containers. The assumed condition in the Waste Storage Facilities DSA for all TRU waste scenarios is that the waste is confined in approved TRU waste containers. Opening TRU waste containers is outside the scope of work at the Waste Storage Facilities.

   Basis: This SAC ensures waste is confined in closed metal containers. Opening TRU waste containers is outside the scope of work at the Waste Storage Facilities.

5. Approved TRU waste containers shall not be staged less than 130 m from the Greenville Road fence line (east of the B693 structure).

   Safety Function: The accident analysis in Section 3.4 of the Waste Storage Facilities DSA assumed that releases of TRU waste occurred no less than 130 m from the site boundary (Greenville Road fence line). Thus, this distance is an assumed condition in the accident analysis in Section 3.4 of the Waste Storage Facilities DSA, and serves to limit the consequences to the off-site public.

   Basis: This SAC provides assumptions in the DSA since 130 m is the minimum distance to the fence line assumed for postulated TRU waste accidents involving staged waste in the hazard and accident analyses.

6. Only waste in metal containers and on metal pallets shall be allowed in TRU waste storage areas.

   Safety Function: The use of metal containers and pallets for waste stored in TRU waste storage areas limits the potential for fire initiation and propagation during operational or other events in TRU waste storage areas by limiting available combustibles. This is a credited control for waste handling and natural phenomena hazard scenarios in the hazard analysis. This control serves to ensure that low-level, hazardous, and other wastes that can be stored coincident with TRU waste are in non-combustible packaging and on non-combustible pallets.

   Basis: This SAC limits the potential for fire initiation and propagation during operational or other events in TRU waste storage areas to mitigate consequences from fires involving TRU waste.

5.5.3 Criticality Safety Program

A criticality safety program shall be established, implemented, and maintained in accordance with *ES&H Manual* Document 20.6, “Criticality Safety,” to ensure that all Waste Storage Facilities operations and activities are reviewed, evaluated, and documented by LLNL criticality safety engineers in accordance with all contractor-applicable provisions of DOE Order 420.1A (DOE 2002). Any detailed controls shall be documented in the FSPs. Operations and storage of waste in the Waste Storage Facilities shall be controlled such that an inadvertent criticality event is precluded.

5.5.4 Radiation Protection Program

A radiation protection program shall be established, implemented, and maintained to ensure that radiation exposure to employees, subcontractors and visitors is controlled in accordance with the requirements of 10 CFR 835, as implemented in Document 20.5, “Occupational Radiation Protection: Implementation of 10 CFR 835,” in the LLNL *ES&H Manual* (LLNL latest revision-a).

5.5.5 Hazardous Material Protection Program

A Hazardous Material Protection program SHALL be established, implemented, and maintained to ensure that exposures to employees, subcontractors, visitors, and members of the general public are controlled in accordance with the LLNL Hazardous Materials Protection Program, as implemented in Document 14.1, “Chemicals,” in the ES&H Manual.

A portion of the Hazardous Material Protection Program that is unique to the Waste Storage Facilities is the Single Container Inventory Limit Program (SCIL), which is designed to protect the public and co-located workers from chemical releases. This program limits the quantity of chemical that can be stored in any one container based on a series of criteria such as the toxicity and vapor pressure of the material.

5.5.6 In-service Inspection & Test, and Maintenance Programs

An in-service inspection & test program and maintenance program are established, implemented, and maintained to ensure the integrity of the Design Features in Section 5.6. The In-service Inspection & Test Program includes the TRU waste container maintenance program and building inspection program as described below. Inspections and tests are performed by qualified personnel.

A TRU waste container maintenance program is implemented and maintained to preserve container integrity and minimize the likelihood of flammable gas buildup. This program includes the following:

- Upon acceptance, visually verifying that vents are present on all approved TRU waste containers, except TRU oversize boxes and LLW converted to TRU waste after assay.
- If a TRU waste container is dropped, the container must be inspected to determine if the drop caused significant damage. The inspection must be performed as soon as the appropriate safety precautions can be implemented, but at least within one working day of the drop. Corrective action, such as overpacking damaged containers, should be implemented as soon as possible.
- Weekly inspections of TRU waste container integrity to include checks for rusting, corrosion, damage, denting, swelling, and damage to filter vents.

This program is implemented through the FSPs and RHWM procedures.

A building inspection program is implemented and maintained to ensure that the B625 and B696R structural systems meet their applicable DOE PC-2 criteria. This program includes inspections every five years or less by a qualified engineer (e.g., structural or civil) to verify that significant physical deterioration or damage of the structural systems as described in Section 4.4.2.2 has not occurred. The partition between B696R and B696S is inspected under the building inspection program every five years because the wall serves as a boundary between the DWTF Storage Area and the B695 Segment of DWTF. Any deficiencies identified will be evaluated for potential impact on stored TRU waste containers and repaired when approved.

This program is implemented through the FSPs and RHWM programs or procedures.

5.5.7 Fire Protection Program

A Fire Protection Program SHALL be established, implemented, and maintained to minimize the likelihood of fire in accordance with all contractor-applicable provisions of DOE Order 420.1A (DOE 2002), as implemented in Document 22.5, “Fire,” in the *ES&H Manual* and the FSPs. Key provisions of this program are:

- Combustible loading is limited to an average of 7 pounds of equivalent ordinary combustibles per square foot in fire areas storing TRU waste, excluding waste containerized in metal packaging.
- Only incidental quantities of flammable or combustible liquids (less than the exempt quantities for the occupancy type) are allowed, except in designated flammable/combustible liquid storage areas.
- Only non-combustible pallets are used for storing TRU waste containers.
- A 20-ft exclusion zone is maintained between the DWTF Storage Area and the B695 Segment of DWTF, except between B696S and B696R, which are separated by a fire-resistive partition. In addition, the exclusion zone is expanded between adjacent roll-up doors in B696 near the segment boundary. This prevents fire from impacting both segments through adjacent roll-up doors.
- Inspection, testing, and maintenance of fire suppression systems is performed based on applicable NFPA requirements.

- The partition between B696R and B696S is inspected monthly.
- Trucks are not allowed inside buildings that are storing TRU waste.

This does not prohibit the use of propane, diesel, gasoline, or electric powered forklifts. Propane, diesel, and gasoline powered forklifts cannot be stored inside buildings storing TRU waste.

Issues identified from inspection, testing, maintenance, or assessment activities related to the RHWM fire suppression systems and B696S/B696Rpartition would be evaluated for their impact on the ability of the system to perform its safety function. If the system is found to be impaired such that the safety function is compromised, compensatory measures consistent with NFPA would be implemented to minimize the potential change in the fire hazard.

5.5.8 Training Program

A training program shall be established, implemented, and maintained to ensure that personnel responsible for RHWM operations are trained and qualified, as applicable, to perform their assigned responsibilities safely. This program includes qualified forklift and crane operators who handle waste containers, or who operate a forklift or crane in the vicinity of waste containers; such personnel shall be trained and licensed in accordance with LLNL requirements, with specific reference to safe practices for lifting and handling waste containers. The *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (TIM) (LLNL latest revision-b) addresses the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities* (DOE 1994).

5.5.9 Emergency Preparedness Program

An emergency preparedness program shall be established, implemented, and maintained to ensure that RHWM personnel are trained (in accordance with the RHWM TIM) to react appropriately to emergencies, whether local or site-wide. This program is implemented in Document 22.1, “Emergency Management,” in the *ES&H Manual*, in the RHWM Contingency Plan (LLNL latest revision-c), and in the FSPs. This program includes personnel response procedures and evacuation routes. The *LLNL Emergency Plan* describes the system’s organizational elements, interfaces, authorities, responsibilities, resources, and actions to be taken in response to emergencies. The FSPs and the Contingency Plan address short-term response actions that are the responsibility of the RHWM Division.

5.5.10 Configuration Management Program

A configuration management program shall be established, implemented, and maintained to ensure consistency between the appropriate design requirements, physical configuration, and documentation of SSCs necessary to protect workers and the public as described in Document 41.2, “Configuration Management Program Description,” in the *ES&H Manual*. This program includes designated system engineers. The USQ process is performed in accordance with the LLNL Unreviewed Safety Question process as described in Document 51.3, “LLNL Unreviewed Safety Question (USQ) Procedure,” in the *ES&H Manual*.

5.5.11 Traffic Control Program

A traffic control program shall be established, implemented, and maintained to provide protection from vehicular traffic for TRU waste in the yard. The traffic control program is intended to limit the speed of vehicles while in the yard and includes speed limits (15 mph) posted in the yard and vehicles required to stop at the yard gate before entering. This program is implemented through the FSPs.

5.6 Design Features

The following are design features identified in Chapter 3 to be included in the TSRs: TRU waste containers; the B625 and B696R structures; and the B696S/B696R partition.

The following are Equipment Important To Safety:

- B625 Structural System (Safety Significant SSC)
- B625 Fire Suppression System (Important Defense-In-Depth)
- B693 Fire Suppression System (Important Defense-In-Depth)
    - Wet Pipe Fire Suppression System
    - Foam Fire Suppression System
    - Fire Alarm System
- B696R Structural System (Safety Significant SSC)
- B696S/B696R Partition (Safety Significant SSC)
- B696R Fire Suppression System (Important Defense-In-Depth)
- TRU Waste Containers (Safety Significant SSC)

5.7 Interface with TSRs from Other Facilities

No TSRs from facilities located near the Waste Storage Facilities directly affect this safety basis. The partition between B696R of the Waste Storage Facilities and B696S of the B695 Segment of the DWTF is considered an interface because it is shared by both nuclear facilities. This wall is inspected at established intervals to ensure it maintains its function.

5.8 References

DOE (1994), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*. DOE Order 5480.20A, Department of Energy, Washington, DC, November 1994.

DOE (1997), *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*. DOE-STD-1027-92, Change Notice 1. U.S. Department of Energy, Washington, DC, September 1997.

DOE (2002), *Facility Safety*. DOE Order 420.1A, U.S. Department of Energy, Washington, DC, May 2002.

DOE (2005). *Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement*, DOE/EIS-0348, DOE/EIS-0236-S3, March 2005.

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*. DOE-STD-3009-94, Change Notice 2. U.S. Department of Energy, Washington, DC, March 2006.

HC/AB-B696-0301, "Fire involving flammable liquids and separation distances," Joong M. Yang, Lawrence Livermore National Laboratory, Livermore, CA, March 2003.

LLNL (2006), Memo from Thom Kato to Jack Sims, "Modification to Individual Container Limits for Radioactive Waste Storage at Building 625 (B625)," Lawrence Livermore National Laboratory, Livermore, CA, July 10, 2006.

LLNL (latest revision-a), *Environment, Safety and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA UCRL-MA-133867, latest revision.

LLNL (latest revision-b), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA UCRL-AR-116655, latest revision.

LLNL (latest revision-c), *Contingency Plan for Radioactive and Hazardous Waste Management Facilities: Area 612, Area 514, Building 233 CSU, and the Decontamination and Waste Treatment Facility*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-127066, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 6
PREVENTION OF INADVERTENT CRITICALITY

6.1 Introduction

The Waste Storage Facilities are Category 2 nuclear facilities for the storage of containerized radioactive waste. The radioactive waste stored in these facilities consists of low-level waste (LLW), transuranic (TRU) waste, mixed waste, and combined waste. The fissionable materials in LLW are mostly Nat-U/Dep-U and those in TRU waste are fissile materials, primarily Pu-239. Therefore, TRU waste is more of a criticality safety concern.

The Waste Storage Facilities are Category 2 nuclear facilities based on their total fissile materials inventories. The average fissile materials loading in individual TRU waste containers is approximately 10 g Pu-239 fissile gram equivalent (FGE). The potential for inadvertent criticality is predicated on the implementation of the LLNL criticality safety program and the scope of the facility operations. Criticality safety controls developed for these facilities are implemented in the Facility Safety Plans (FSPs). The double contingency principle and the defense-in-depth approach have been used in the development of the criticality safety controls to prevent inadvertent criticality for all operations.

This chapter describes the Criticality Safety Program for the Waste Storage Facilities and the means by which inadvertent criticality is prevented. This chapter includes the following:

- 6.2 Requirements – Lists the LLNL Criticality Safety standards in the NNSA/LLNS Contract Appendix G (NNSA/LLNS 2007) including the relevant DOE Orders required for establishing the safety basis of the facilities specific to this chapter.
- 6.3 Criticality Concerns – Discusses the probability of the occurrence of an inadvertent criticality accident in the facilities.
- 6.4 Criticality Safety Controls – Discusses the criticality safety controls in the facilities including a general discussion on the criticality safety basis and the approach used to ensure criticality safety. Also included in this section is the application of the double contingency principle in criticality safety.
- 6.5 Criticality Protection Program – Describes the Criticality Safety Program for the facilities and major elements of the criticality safety programmatic infrastructure needed to ensure that the criticality safety program is effective. Topics covered include Criticality Safety Plans and Procedures, Criticality Safety Training, and self-assessments.
- 6.6 Criticality Instrumentation – Justifies that a criticality accident alarm or detection system is not required in any of the Waste Storage Facilities.

6.2 Requirements

DOE Orders and LLNL NNSA/LLNS Contract Appendix G standards (NNSA/LLNS 2007) and procedures for establishing the Waste Storage Facilities criticality safety basis are listed below:

U.S. Department of Energy

DOE O 420.1A (§4.3 Nuclear Criticality Safety, excluding ANSI/ANS 8.9, 8.10, and 8.17)	*Facility Safety* (2002). Note that DOE O 420.1A invokes the relevant ANSI/ANS-8.xx series of standards on criticality safety. Therefore, those standards are not listed separately.

ANSI Standards

ANSI/ANS-8.20-1991	*Nuclear Criticality Safety Training*
ANSI/ANS-8.22-1997	*Nuclear Criticality Safety Based on Limiting and Controlling Moderators*
ANSI/ANS-8.23-1997	*Nuclear Criticality Accident Emergency Planning and Response*

LLNL Manuals and Reports

UCRL-MA-133867	LLNL *Environment, Safety, and Health Manual*, Document 20.6, “Criticality Safety”

6.3 Criticality Concerns

The Waste Storage Facilities deal with the storage of radioactive waste in containers. Many of these containers include fissionable materials. These fissionable materials are mostly in the form of Pu-239 in TRU waste and Nat/Dep-U in low-level waste. Pu-239 poses the main criticality concern. The average TRU container includes approximately 10 grams of Pu-239 FGE. Although the total fissionable material inventory of these facilities exceeds that of a critical mass, the material form, packaging and segregation preclude the possibility of an inadvertent criticality.

Criticality safety evaluations performed by the LLNL Criticality Safety Division indicate that all normal and credible upset conditions for these facilities are safe with respect to criticality safety (LLNL 2003). These evaluated optimized conditions with very conservative assumptions on the fissile drum contents, which are much higher than the average drum contents stored at this facility. O’Connell and Greybeck performed a probabilistic risk assessment (PRA) on RHWM storage operations in 2001 (O'Connell 2001). Their results show that inadvertent criticality is beyond extremely unlikely (or incredible). Based on the RHWM TRU waste container fissionable material contents and the scope of RHWM operations, their PRA work remains valid for 200 Pu-239 FGE containers and can be used as a demonstration of the incredibility of inadvertent criticality for current RHWM storage operations.

6.4 Criticality Safety Controls

Criticality Safety in the Waste Storage Facilities is ensured by a combination of engineering and administrative controls on:

- container sizes and types
- quantities of fissionable materials
- amount of moderators and reflectors, and
- interaction between drums and arrays

Furthermore, a rigorous peer review process and a formal training program are in place to ensure effective implementation of the criticality safety controls.

Geometry, interaction, moderation, and mass are the primary criticality safety parameters that are important in developing criticality controls. For RHWM operations including storage operations at the Waste Storage Facilities, the principal defense against inadvertent criticality is to control the amount of fissionable materials so that the accumulation of a critical mass can be effectively prevented.

The overall approach in developing criticality controls for the Waste Storage Facilities operations emphasizes container controls and storage array controls. Criticality controls are developed based on a detailed understanding of operations including normal and credible upset conditions, system reactivity analysis, and formulation of defense-in-depth barriers to ensure subcritical configurations. Detailed neutronic evaluations were performed to assess the adequacy of the criticality controls for containers and arrays.

6.4.1 Engineering Controls

Since these are storage facilities, the engineering control used for waste handling and storage operations is the use of approved storage containers, such as steel drums and steel waste boxes for TRU waste storage. Containers are used to provide spacing and to isolate the fissionable materials in adjacent drums to minimize neutron interaction between drums.

6.4.2 Administrative Controls

All operations involving fissionable materials in the Waste Storage Facilities storage operations are subject to administrative criticality safety controls, which are applied to drums and arrays. The drum controls include fissionable material mass limits as well as moderator and reflector types and mass limits. The array controls include configuration (uniform or mixed-container), spacing, and drum-stacking. The fissile material inventory per container is limited to 200 Pu-239 FGE.

Guidance to fire fighters is provided by the assignment of a Criticality Hazard Type for each operation in accordance with the definitions given in the LLNL *ES&H Manual*, Document 20.6, “Criticality Safety.” For the Waste Storage Facilities there are no restrictions on the use of water for fire suppression purposes.

Evaluated Containers

Programmatic controls are implemented in the various waste acceptance procedures as well as the FSPs to ensure that each container type used to store fissionable material contains no more than the authorized quantity of fissile material. These controls also incorporate limits on reflectors and moderators.

Storage Array Configuration

Programmatic controls are implemented in the FSPs to ensure that the storage configuration of the waste is safe. These controls include necessary configuration requirements for the various types of containers that may be stored in the Waste Storage Facilities.

6.4.3 Application of Double Contingency Principle

DOE Order 420.1A invokes ANSI/ANS-8.1-1983, R88 “Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors” and modifies the Double Contingency Principle to read “Process design shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.”

For the Waste Storage Facilities operations, criticality safety is assured through the application of multiple (more than two) barriers exceeding the requirements of the Double Contingency Principle. For example, storage arrays will have the following barriers: fissionable materials mass limit, solid moderator limit, reflector limit, container size, and array spacing controls. A probabilistic risk assessment evaluation covering all credible external and internal events has concluded that there is no credible risk of a criticality accident.

In summary, the criticality safety controls in the FSPs ensure that a criticality accident is not possible for all normal and credible upset conditions. The double-contingency principle is strictly followed in the development of the criticality safety controls for the Waste Storage Facilities operations.

6.5 Criticality Protection Program

The LLNL Criticality Safety Program is defined in the LLNL *ES&H Manual*, Document 20.6, “Criticality Safety.” This program meets applicable regulatory requirements and applies to all LLNL nuclear facilities including the Waste Storage Facilities. Key areas covered in this program are discussed below.

6.5.1 Criticality Safety Organization

Specific responsibilities of the Waste Storage Facilities personnel and supporting organizations are described in the FSPs. Descriptions of roles and responsibilities for various line organizations and support organizations, such as the Criticality Safety Division, are described in detail in Document 20.6, “Criticality Safety,” of the LLNL *ES&H Manual*.

6.5.2 Criticality Safety Plans and Procedures

Formal documented criticality safety evaluations (CSEs) are required for all fissionable material operations in the Waste Storage Facilities. Criticality safety mass limits and controls are derived from the criticality safety evaluations. The LLNL Criticality Safety Section is responsible for performing CSEs.

All CSEs are performed by qualified criticality safety engineers. These CSEs meet the following minimum requirements:

- CSEs are performed to the LLNL criticality safety requirements found in Document 20.6, "Criticality Safety," in the *ES&H Manual*.
- CSEs show that all normal and credible upset operating conditions are subcritical under the Double Contingency Principle.
- CSEs document the calculations and expert professional judgments used in determining that criticality safety is ensured.
- CSEs for new operations, not currently addressed by an approved CSE, are completed before any fissionable material is processed, stored, or relocated.
- All CSEs are subject to a formal peer review process prior to their approval.

Criticality safety in the Waste Storage Facilities is governed by the FSPs. CSEs provide the technical bases for the criticality controls implemented in the FSPs.

6.5.3 Criticality Safety Training

Fundamentals of Criticality Safety for RHWM Personnel or its equivalent is required for the Waste Storage Facilities personnel. The LLNL Criticality Safety Section provides this training. On-the-job training is provided by the Facility Point of Contact with assistance provided by criticality safety engineers.

6.5.4 Determination of Operational Nuclear Criticality Limits

The development of operational nuclear criticality limits is based upon assessment of the bounding conditions for normal operations and credible process upset conditions. Since the Waste Storage Facilities deal with storage of radioactive wastes, the process upset conditions for these facilities are primarily those associated with waste handling and storage operations.

The configurations of fissionable materials in normal operations are less reactive than upset conditions, such as loss of controls on fissionable materials mass. Therefore, the bounding scenarios for credible upset conditions bound the reactivities of normal operations.

All of the normal operations and credible upset conditions have been demonstrated to be subcritical. No safety-class or safety-significant SSCs have been identified related to criticality safety concerns. The LLNL Criticality Safety Program is a programmatic administrative control. A probabilistic risk assessment by O'Connell and Greybeck also independently showed that inadvertent criticality is not credible for RHWM waste storage operations (O'Connell 2001).

6.5.5 Criticality Safety Inspections/Audits

As an inadvertent criticality event is not credible in the Waste Storage Facilities, formal criticality safety audits are not required per LLNL *ES&H Manual*, Document 20.6, "Criticality Safety." However, as a Category 2 facility, inspections, walkthroughs, or other assessments may be performed at the request of

Facility Management or as deemed appropriate by criticality safety engineers to ensure effective implementation of criticality safety controls.

6.5.6 Criticality Infraction Reporting and Follow-Up

Infractions are deviations from criticality safety controls. The LLNL *ES&H Manual*, Document 20.6, “Criticality Safety,” specifies mandatory actions to be taken upon discovery of an actual or suspected infraction.

6.6 Criticality Instrumentation

The Criticality Safety Section has performed criticality safety evaluations to support the operations in these facilities and to ensure that a criticality accident is not possible under all normal and credible upset conditions. Since inadvertent criticality is not credible, a criticality accident detection or alarm system is not required for the RHWM waste storage operations per Paragraphs 4.3.3.b and 4.3.3.e of DOE Order 420.1A. Furthermore, there are no safety-class or safety-significant equipment or systems identified.

6.7 References

DOE (2002), *Facility Safety*. DOE Order 420.1A, §4.3 Nuclear Criticality Safety, excluding ANSI/ANS 8.9, 8.10, and 8.17, U.S. Department of Energy, Washington, DC, May 2002.

LLNL (latest revision). *Environment, Safety, and Health Manual*. Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

LLNL (2003), CSM 1344, “CRITICALITY SAFETY EVALUATION On the Use of 200-gram Pu Drum Mass Limit for RHWM Waste Storage Operations,” Lawrence Livermore National Laboratory, August 2003.

W.J. O'Connell and E.M. Greybeck (2001). *Probability Analysis of Absence of Credible Criticality in Waste Storage in the HWM Facility*. Lawrence Livermore National Laboratory, CA, UCRL-ID-143685, April 2001.

CHAPTER 7
RADIATION PROTECTION

7.1 Introduction

This chapter addresses the Radioactive and Hazardous Waste Management (RHWM) Division's radiation protection program. In addressing occupational radiation protection for the Waste Storage Facilities, the facility safety plans (FSPs) for these facilities implement site requirements specified in the LLNL *ES&H Manual* (LLNL latest revision-a).

7.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facility, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy (DOE)

DOE Order 435.1	Radioactive Waste Management
DOE Order 420.1A	Facility Safety
DOE Order 5400.5, Change Notice 2	Radiation Protection of the Public and the Environment

Code of Federal Regulations

10 CFR 835	Occupational Radiation Protection
10 CFR 830	Nuclear Safety Management

7.3 Radiation Protection Program and Organization

A radiation protection program is established, implemented, and maintained to ensure that radiation exposure to employees, subcontractors, and visitors is controlled in accordance with requirements of 10 CFR 835, *Occupational Radiation Protection* (10 CFR 835), as implemented in *ES&H Manual* Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835."

The radiation protection program ensures that the Waste Storage Facilities are maintained and operated in accordance with 10 CFR 835. In particular, the radiation protection program assures that the occupational radiation exposures are maintained as-low-as-reasonably-achievable (ALARA) below 5 rem per year by design, radiation and contamination control, and procedures and training.

The primary control for radiation protection is the container holding the waste and engineered controls in the design of the building that is storing the waste. The walls and roof provide a protective enclosure.

Administrative controls and protective clothing provide secondary protection. ALARA concepts are applied to minimize exposures. Facility designs along with administrative requirements ensure that DOE stipulations for maximum dose are not exceeded. Radiation air monitoring devices are brought in, as required, for emergency situations or for monitoring requested by the health physicist.

The Hazard Control Department assigns ES&H teams to oversee health and safety practices for each LLNL program. ES&H Team 1, which includes a health physicist, oversees the safety of the Waste Storage Facilities. Additional organizational summary material is provided in Chapter 17, *Management, Organization, and Institutional Safety Provisions.*

7.4 ALARA Policy and Program

It is the policy of the DOE and LLNL that exposure of personnel to ionizing radiation associated with LLNL operations is to be maintained as low as reasonably achievable below regulatory limits. The ALARA objective is achieved by integrating the following factors:

- Management involvement.
- Education and training.
- Facility designs.
- Safety procedures.
- Radiation dosimetry.
- Workplace monitoring.
- Environmental monitoring.
- Emergency preparedness.
- Program evaluations.
- ALARA goal-setting.
- Benefit versus risk analyses.

LLNL's detailed ALARA program is provided in *ES&H Manual* Document 20.4, "LLNL Occupational Radiation Protection ALARA Program." The ALARA program is applicable to the Waste Storage Facilities activities.

7.5 Radiological Protection Training

Radiological protection training is required for all personnel appropriate to individual job assignments. General employees receive general radiation safety training prior to potential exposure. Allowance may be made for previous DOE training on generic radiation-safety topics (i.e., those not specific to a site or facility), provided the training had been received at another DOE site or facility within the past two years. General employees are instructed in radiation safety during new-employee orientation. Retraining is provided when there is a significant change to the radiological protection policies and procedures that affects general employees. Retraining is conducted at intervals not to exceed two years. Retraining is accomplished by means of a self-study booklet that is sent to employees.

Radiological-worker training and retraining programs are in place for employees at LLNL who work on, with, or near ionizing-radiation-producing equipment or radioactive materials. Training or retraining is required prior to unescorted access into radiation areas or radiological buffer areas. Initial training is offered by the Hazard Control Department. Supervisors are required to identify workers who require training and ensure they attend the training. The Hazard Control Department provides the requisite training. In addition, on-the-job training (OJT) is provided by qualified instructors to customize the concepts of classroom training to a worker's actual work assignment.

Training programs for health and safety technicians are conducted at intervals not exceeding two years. The training familiarizes technicians with the fundamentals of radiation protection and procedures for maintaining exposures ALARA. The program includes classroom and applied training. The level of facility-specific training is commensurate with a technician's assignment.

Specialized radiological control courses are also available from the Hazard Control Department. The need for other courses is at the discretion of the supervisor or according to advice given by the health physicist responsible for the area. Direct supervisors are required to complete training as specified in the *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (see Chapter 9).

7.6 Radiation Exposure Control

This section summarizes the plans and procedures for controlling external occupational exposure to radiation, spread of contamination, and inhalation or ingestion of radioactive materials.

7.6.1 Administrative Limits

The principal occupational radiation safety consideration in the Waste Storage Facilities is to minimize radiation exposure and assimilation of radioactive materials by employees. Activities in the Waste Storage Facilities comply with the intent of applicable DOE requirements as implemented by site policies and programs specified in *ES&H Manual* Document 20.1, "Occupational Radiation Protection;" Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials;" Document 20.4, "LLNL Occupational Radiation Protection ALARA Program;" and Document 20.5, "Occupational Radiation Protection: Implementation of 10 CFR 835."

The FSP and the *ES&H Manual* provide information on isotope source handling and use, radiation safety systems, and safety procedures that provide administrative controls to prevent excessive radiation exposure. Each facility safety plan contains administrative limits on processes that are derived in accordance with the Radiation Protection Program to ensure that worker doses from normal operations and potential accidents remain ALARA.

Radioactive waste accepted by RHWM is limited to contact-handled waste. Therefore, the surface dose rate of a radioactive waste container may not exceed 200 mrem/hr.

It is LLNL policy to comply with radiation protection standards given in 10 CFR 835, which specifies an annual radiation dose limit of 5 rem to the whole body, 50 rem to the skin and extremities, and 15 rem for the lens of the eye. When whole-body doses can exceed 100 mrem/yr, ALARA goals will be established. Over the past 2 years, there have only been two person-specific ALARA goals established for work in RHWM facilities. The ES&H Team health physicist determines, along with the Program, whether there is a need to establish any ALARA goal or program based on the most current dosimetry and bioassay results. Other ALARA reviews are conducted as described in *ES&H Manual* Document 20.4.

7.6.2 Radiological Practices

To prevent personnel contamination, LLNL provides protective apparel for individuals working with radioactive materials. All individuals working with dispersible radioactive materials are required to wear, at a minimum, a laboratory coat and gloves. Additional clothing and shoes may be specified, as needed. Radioactive contamination of surfaces outside work enclosures is maintained ALARA. Articles or equipment to be used in nonradioactive work areas or outside LLNL are decontaminated to levels that allow for unrestricted use, as required by the *ES&H Manual*, Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials." Waste containers are surveyed to verify external surfaces meet free release limits prior to being allowed in the Waste Storage Facilities.

Radiological areas are identified and maintained in accordance with 10 CFR 835. In general, all storage areas where radioactive materials are present are posted with warning signs containing applicable safety instructions and information for the radioactive materials present.

Access control to the Waste Storage Facilities is enforced. Only those personnel approved by the appropriate supervisors are authorized to work in these facilities. Such individuals are required to complete radiation worker training prior to working in an area where radioactive materials and waste are handled. Personnel not regularly assigned to the Waste Storage Facilities are required to prearrange access and be escorted while in the operational zones.

7.6.3 Dosimetry

Personnel entering the Waste Storage Facilities are required to wear a dosimeter designed to measure radiation exposure to beta and gamma and neutron radiation as applicable. Personal alarming dosimeters are worn when deemed necessary by the health physicist. The health physicist determines the appropriate type of dosimeters needed for various types of radioactive-material-handling activities. ES&H Team 1 health physicists are responsible for promptly notifying RHWM management and the worker, as required by the ES&H Manual or associated Dosimetry Program Manual, in the event of unexpected results from external or internal dosimetry. The health physicist is also responsible for investigating and evaluating the cause with priority given to preventing any further such exposures/intakes.

As stated in Chapter 6 of this report, a criticality accident is not a credible event in the Waste Storage Facilities. Thus, there are no criticality alarm systems, and nuclear accident dosimeters are not required.

7.6.4 Respiratory Protection

Respiratory protection devices are available for emergency response by trained personnel or for operations that the Industrial Hygienist and/or the Health Physicist determine respiratory protection is necessary. The devices are used when engineering controls (e.g., safety enclosures or proper ventilation) are not feasible or when emergency conditions develop. The need for respiratory protection is determined by the health physicist.

7.7 Radiological Monitoring

The Hazard Control Department administers the program that meets 10 CFR 835 and *ES&H Manual* Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials," requirements. This program includes:

- Measuring ambient radiation fields.
- Monitoring for airborne contamination.
- Surveying for surface contamination.

Qualified individuals in the Hazard Control Department also select, obtain, calibrate, distribute, and maintain radiation-monitoring instruments, as needed.

7.8 Radiological Protection Instrumentation

The health physicist supporting the RHWM Division prescribes a radiation monitoring program that meets 10 CFR 835 requirements. This program includes the type of monitoring (e.g., air, contamination surveys), the type of instrumentation needed, the type of detectors, sensitivities of instruments, and other information.

7.9 Radiological Protection Record-Keeping

Dosimeter readings are obtained and recorded, and statements of accumulated external occupational radiation doses are provided annually to all employees, as required by 10 CFR 835, *Occupational Radiation Protection*, per NNSA/LLNSContract DE-AC52-07NA27344. Under existing programs, employees are notified of any positive radiation dose. Any radiation dose that exceeds the limits, as stated in *ES&H Manual* Document 20.4, "LLNL Occupational Radiation Protection ALARA Program," is reported to the supervisor and to the person involved as soon as the information is available. The Hazard Control Department investigates the cause of such doses and maintains and stores all occupational radiation dose records for LLNL. Records are maintained per 10 CFR 835.

7.10 Occupational Radiation Exposures

The collective total effective dose equivalent (TEDE) for all RHWM workers between 2000 and 2005 ranged from 0.071 person-rem (2001) to 1.794 person-rem (2004) (Le 2005). Per 10 CFR 835, the maximum allowable exposure limit (TEDE) is 5 rem/yr. The annual collective TEDE for all RHWM personnel based on historical data is less that the individual maximum allowable dose limit of 5 rem.

7.11 References

CFR (10 CFR 835), *Occupational Radiation Protection*, U.S. Department of Energy, Code of Federal Regulations, Title 10, Office of the Federal Register, Washington, DC.

Le (2005). Email from Quang Le to Heather Larson, LLNL, December 2, 2005.

LLNL (latest revision-a), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

NNSA/LLNS (2007), *Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security*, No. DE-AC52-07NA27344, effective October 1, 2007.

CHAPTER 8
HAZARDOUS MATERIAL PROTECTION

8.1 Introduction

This chapter includes information on LLNL's Hazardous Material Protection Program, which is a part of the overall Health and Safety Program. The Health and Safety Program is devoted to identification, evaluation, and control of environmental factors found in the workplace as they apply to all facilities.

The objective of this chapter is to identify applicable aspects of the Hazardous Material Protection Program and to show how they protect against facility hazards and contribute to facility safety. The process for reducing occupational chemical exposures is also described in Section 8.11.

8.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the Waste Storage Facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
10 CFR 851	Worker Safety and Health Program
29 CFR 1910.1200	Occupational Safety and Health Standards

8.3 Hazardous Material Protection Program and Organization

The LLNL Health and Safety Policy, which includes requirements for hazardous material protection, is defined in the *ES&H Manual* (LLNL latest revision-a). The policy is implemented through use of engineering and administrative controls and personal protective equipment (PPE). Procedures provide detailed requirements and responsibilities for implementing each part of the LLNL Health and Safety Policy. It is the policy of LLNL to implement DOE health and safety orders and to comply with prescribed standards and local, state, federal regulations, and Lawrence Livermore National Security, LLC policies.

All management levels are responsible for developing and implementing procedures to protect workers against hazards in the workplace. LLNL also has the Hazard Control Department as one of its environment, safety, and health (ES&H) organizations. By providing information on the radioactive and hazardous properties of materials and on relevant regulations, by recommending methods for control of hazardous materials, and by monitoring the work environment, this department, through its ES&H teams, assists supervisors and employees in maintaining safe work areas. The head of the Hazard Control ES&H Team (Team 1) assigned to the Radioactive and Hazardous Waste Management (RHWM) Division interacts directly with the Facility Manager.

The Waste Storage Facilities are monitored by ES&H Team 1. This team consists of multidisciplinary specialists, including at least one industrial hygienist. Most LLNL industrial hygienists are certified by the American Board of Industrial Hygiene and/or have graduate degrees in industrial hygiene or a closely related field. The industrial hygienists provide the primary guidance for hazardous material protection and interface with facility staff and other ES&H team members, including health and safety technicians, safety engineers, health physicists, fire protection engineers, safety analysis specialists, safety and health trainers, nuclear criticality safety specialists, Environmental Analysts, and Health Services Department personnel.

8.4 ALARA Policy and Program

Although there is no specific ALARA program for hazardous materials, a number of programs serve to maintain employee exposures to hazardous substances at levels below those of regulatory guidelines. The following documents from the *ES&H Manual* establish policy and programs for hazardous materials:

- Document 10.2, “LLNL Health Hazard Communication Program”
- Document 11.1, “Personal Protective Equipment”
- Document 14.1, “LLNL Chemical Safety Management Program”

These documents provide guidance and identify responsibilities for maintaining all exposures to hazardous materials well within DOE limits and federal and state regulations. All management levels of LLNL are responsible for developing and implementing controls and procedures to protect workers against hazards in the workplace. The facility safety plan (FSP) is the basic safety and health plan that must be followed by all personnel present within the building or area. Safety and health requirements specific to a hazardous waste operation are presented in the FSP or an Integration Work Sheet with a Safety Plan addendum (IWS/SP).

8.5 Hazardous Material Training

The LLNL RHWM Training Program provides LLNL personnel with the necessary knowledge and skills to perform their duties safely and in an environmentally sound manner. RHWM personnel manage the Waste Storage Facilities. They are responsible for storing and treating waste and preparing shipment of LLNL’s waste for offsite treatment and/or disposal. RHWM operations personnel working in the Waste Storage Facilities are trained in chemical safety. Training is provided for RHWM personnel as described in *ES&H Manual* Document 40.1, “LLNL Training Program Manual” and the *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL latest revision-b). The ES&H Team support for RHWM receive either general or occasional site worker training as described in 29 CFR 1910.120(e). Emergency response services beyond these training levels are provided by the LLNL/Alameda County Fire Department.

8.6 Hazardous Material Exposure Control

8.6.1 Hazardous Material Identification Program

All waste received at the Waste Storage Facilities is properly identified, prior to delivery, on a waste disposal requisition (WDR) form. Appropriate labels are affixed to waste containers in the waste accumulation area. The label is cross-referenced to the accompanying WDR form by its unique number. Potential radioactive (TRU and low-level), hazardous, mixed, and combined wastes are identified and documented through the following:

- Knowledge and assessment of the operations.
- Periodic walk-through surveys.
- Review of proposed projects and facilities.
- Maintenance of a hazardous material tracking system.

To assess potential hazards, all programs, facilities, and buildings are subject to review and evaluation by Hazards Control Department personnel. Results of the reviews are forwarded to the appropriate department so that any deficiencies can be corrected. Records of reviews are maintained by the Hazard Control Department. The program and activities that identify, analyze, and control potential hazardous material are described in the *ES&H Manual* Document 14.1, "LLNL Chemical Safety Management Program," and the FSP.

8.6.2 Administrative Limits

Several exposure limits are available. They are permissible exposure limits (PELs) established by the Occupational Safety and Health Administration (OSHA) or threshold limit values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH). The lower of the two values for the same chemical is established as the administrative limit. DOE has established in 10 CFR 850 an "action level" for beryllium exposure. This action level triggers a series of additional controls if reached. LLNL implements this program in the *ES&H Manual* Document 14.4, "Implementation of the Chronic Beryllium Disease Prevention Program Requirements."

In order to limit exposures to co-located workers and to the public from accidents involving chemical waste, RHWM has established the Single Container Inventory Limit (SCIL) Program. An extensive list of toxic chemicals is maintained and updated, as required, listing the limit for each chemical in a container.

Although RHWM handles a large quantity of hazardous waste, the primary waste streams would be described as industrial hazardous waste such as dilute aqueous solutions, paint, oil, solvents, dilute corrosives, and fluorescent tubes. RHWM tracks the amount of chemical waste stored in a relational database. It is extremely difficult to maintain a meaningful real-time summarized inventory. The major difficulties in maintaining such an inventory are:

- Nomenclature - the same chemical can have multiple names
- Concentration - trace quantities in solution are far less toxic than the pure material
- Form - a fine powder is potentially more dangerous than a solid chunk

Because of the difficulty in maintaining a meaningful real-time chemical inventory, RHWM uses the SCIL Program. This program is based on the current Quantity value (Q value) chemical thresholds described in the LLNL ES&H Manual Document 3.1, "Nonnuclear Safety Basis Program," revision March 2004 (LLNL 2004). By using the Q values, the SCIL Program is designed to ensure that under a worst-case spill scenario, the concentration at 100 meters will be at a concentration that maintains the Waste Storage Facilities as Low Hazard facilities.

Before waste can be accepted into RHWM facilities, it goes through a series of reviews. One of these reviews is to verify if the waste meets the SCIL criteria. If it does not, then it is either repacked, shipped offsite from the field, or a calculation is performed to see if it can be safely accepted.

8.6.3 Occupational Medical Programs

LLNL's Medical Monitoring Program, which is implemented by the Health Services Department, is described in *ES&H Manual* Document 10.1, "Occupational Medical Program." This monitoring program includes physical examinations, medical evaluations and record-keeping of hazardous material exposures. Based on a hazard assessment of specific substances described in work control documents, the ES&H Team industrial hygienist in consultation with supervisors and the Health Services Department determine the appropriate medical surveillance programs. Tailored medical surveillance programs for Hazardous Waste Workers, Beryllium Workers, and Respirator Users are common for hazardous waste technicians.

8.6.4 Respiratory Protection

LLNL's respiratory protection program is described in *ES&H Manual* Document 11.1, "Personal Protective Equipment," and in Section 7.6.4 of this document. The process for reducing occupational chemical exposures is also described in Section 8.11.

8.7 Hazardous Material Monitoring

ES&H Manual Document 14.1, "LLNL Chemical Safety Management Program" describes exposure monitoring for chemical hazards. Other sections of the ES&H Manual for specific substances as well as procedures within the Hazards Control Department further detail how hazards are evaluated, monitored, and controlled.

ES&H Manual Document 12.2, "Ventilation," and Document 12.3, "Evaluation and Control of Facility Airborne Effluents," provide the ventilation requirements and acceptance criteria for all new and modified facilities. This document provides the surveillance, maintenance, and systems-failure procedures for existing facilities. Area ES&H teams conduct regular performance checks on all ventilation systems used for hazardous materials.

Monitoring for air and surface contamination is appropriate for initial evaluation of new waste handling procedures or after working conditions have been changed. Results will determine whether periodic monitoring is necessary.

The LLNL Site Annual Environmental Report (LLNL latest revision-c) provides information on the environmental monitoring activities conducted by the Environmental Protection Department. Activities include sampling and reporting results for air, sewage effluent, groundwater, surface water, soil, vegetation, and foodstuffs.

LLNL's environmental activities include radiological and nonradiological monitoring, effluent- and compliance-monitoring, remediation, assessment of radiological releases and doses, and determination of the impact of LLNL operations on the environment and public health.

8.8 Hazardous Material Protection Instrumentation

The Hazard Control Department ES&H Team 1 assists supervisors and employees in maintaining safe work areas by providing information on the hazardous properties of materials and relevant regulations, recommending methods for control, and monitoring the work environment. Instrumentation used for monitoring, sampling, and surveying is selected and placement determined by the appropriately qualified and trained member of the ES&H team (e.g,. IH, HP, IS). Information on the inventory and technical specifications of monitoring instruments are available in the Industrial Hygiene Instrument Laboratory.

8.9 Hazardous Material Protection Record-Keeping

Results of hazardous material monitoring performed by the Hazard Control Department are documented in a report and provided to RHWM and the Health Services Department. Copies are maintained by Hazards Control according to department policies for authorized release only. Occupational exposure records are maintained per regulatory requirements.

8.10 Hazard Communication Program

In compliance with 29 CFR 1910.1200, the Hazard Control Department has a written Health Hazard Communication Program (*ES&H Manual* Document 10.2, "LLNL Health Hazard Communication Program"). The purpose of the program is to ensure that hazardous materials have been evaluated and that this information is communicated to affected employers and employees. Other provisions of the Health Hazard Communication Program include:

- Identification and labeling of hazardous materials.
- Hazardous materials evaluation.
- Information and training.

RHWM implements the Health Hazard Communication Program for operations in the Waste Storage Facilities. Implementation of these provisions is discussed in *ES&H Manual* Document 10.2, "LLNL Health Hazard Communication Program," and in the FSP.

8.11 Occupational Chemical Exposures

Potential for measurable or detectable levels of hazardous materials exists in the Waste Storage Facilities operations. Routine industrial hygiene surveillance of current RHWM operations in the Waste Storage Facilities have not shown exposures above LLNL adopted Occupational Exposure Limits (OELs). Although there have been previous operations with legacy waste materials that have exceeded OELs, none of those operations are currently performed. Controls (e.g., ventilation, respiratory protection) commensurate to the potential hazard shall be evaluated and recommended by the area ES&H Team. A hazard assessment and analysis shall occur prior to the start of an operation. When operational parameters change (e.g., frequency, quantity, location), operations shall be reviewed to ensure adequacy of current control methodologies. Records of exposure assessments are available through the Industrial Hygiene Section.

8.12 References

CFR (29 CFR 1910), *Occupational Safety and Health Standards,* U.S. Department of Labor, Code of Federal Regulations, Title 29. Office of the Federal Register, Washington, DC.

Craig, D.K. (latest revision), Temporary Emergency Evaluation Limits, posting of exposure values on the Web at http://tis-nt.eh.doe.gov/web/chem_safety/teel.html, Westinghouse Safety Management Systems, WSMS-SAE-02-0171, Rev. 19, December 2002 or latest revision.

LLNL (latest revision-a), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

LLNL (latest revision-b), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division,* Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-116655, latest revision.

LLNL (latest revision-c), *Environmental Report*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-50027-96, latest revision.

LLNL (2004). *Environment, Safety, and Health Manual.*Document 3.1, “Nonnuclear Safety Basis Program,” Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, March 2004.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

CHAPTER 9
RADIOACTIVE AND HAZARDOUS WASTE MANAGEMENT

9.1 Introduction

Radioactive and hazardous waste management is the mission and purpose of the Waste Storage Facilities. Although the purpose and operations are described in Chapter 2, the chapter is retained for completeness. The Waste Storage Facilities are Hazard Category 2 nonreactor nuclear facilities. Operations in these facilities are mainly those associated with storage of radioactive and hazardous waste, including TRU waste, LLW, mixed waste, and combined waste, and nonhazardous waste.

9.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facility, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy (DOE)

DOE Order 435.1	Radioactive Waste Management
DOE Order 420.1A	Facility Safety
DOE Order 5400.5, Change Notice 2	Radiation Protection of the Public and the Environment

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
10 CFR 835	Occupational Radiation Protection
40 CFR 262	Standards Applicable to Generators of Hazardous Waste
40 CFR 264	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities

California Code of Regulations

22 CCR 66262	Standards Applicable to Generators of Hazardous Waste
22 CCR 66264	Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities

9.3 Radioactive and Hazardous Waste Management Program and Organization

This section summarizes the radioactive and hazardous waste management program and organization for the Waste Storage Facilities. Included in the discussion is an overview of safety management policies and philosophies used as the basis of the program.

The Waste Storage Facilities include permitted waste treatment and storage facilities regulated under the Hazardous Waste Facility Permit for the LLNL Livermore Site. The permit was issued by the California Environmental Protection Agency Department of Toxic Substances Control (DTSC). LLNL manages hazardous and mixed waste in accordance with the conditions of this permit. The Operation Plan is a part of the Hazardous Waste Facility Permit issued by the DTSC.

9.3.1 Waste Management Program and Safety Management Policies and Philosophies

LLNL implements DOE's ES&H policies and programs through site policies and programs specified in the LLNL *ES&H Manual* (LLNL latest revision-a). RHWM safety management practices are in accord with the LLNL *ES&H Manual* Document 20.2, "LLNL Radiological Safety Program for Radioactive Materials." Guidelines for safe management of waste are also covered in *ES&H Manual* Document 36.1, "Hazardous, Radioactive, and Biological Waste Management Requirements," Document 36.2, "Managing Office and Shop Supplies for Disposal," and Document 36.3, "Management of Satellite and Waste Accumulation Areas for Hazardous and Mixed Waste."

In addition, to perform operations within the Waste Storage Facilities efficiently and safely, controls specified within the facility safety plans (FSPs) are followed. All work in the Waste Storage Facilities beyond activities commonly performed by the public must be authorized with an IWS. Depending on the level of hazards associated with the activity, an SP may also be required.

In the area of radioactive waste management, LLNL's primary objective is to minimize potential impacts to the public and the environment, keeping all impacts ALARA below allowable limits. Waste management operations in the Waste Storage Facilities are also conducted in a manner that minimizes the potential impact to workers.

The Hazard Control Department provides assistance to RHWM supervisors and workers for both radiological and nonradiological occupational safety. The Environmental Protection Department is responsible for assisting RHWM personnel in protecting the environment from operations at the facility. In addition, the management and certification program of LLW is described in the *LLNL Radioactive Waste Program Certification and Quality Assurance Plan* (LLNL latest revision-b).

9.3.2 RHWM Organizational Structure

The RHWM Division Leader/Deputy Division Leader is responsible for overall facility operation and delegates, in writing, the succession of responsibility during any absence. The RHWM Division Leader is responsible for safe operation within the Waste Storage Facilities. Safe operation includes, as necessary, interface requirements with other site organizations and facilities to ensure the availability of fire protection, electric power, utilities, and other items.

The Storage and Disposal Group Leader is responsible for operations at the Waste Storage Facilities. The RHWM group leaders are responsible for overall site safety at RHWM facilities and have control over those activities necessary for safe operation and maintenance. Individuals who carry out health physics and quality-assurance functions have organizational independence.

9.3.3 Waste Management Plans, Procedures, and Training

The *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL latest revision-c) addresses the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*.

Operations and activities in the Waste Storage Facilities must also comply with facility-specific FSPs. FSPs implement policies and programs specified in the *ES&H Manual* and also implement safety basis requirements. An Integration Work Sheet with a Safety Plan addendum (IWS/SP) is written as required for activities not described in the FSP.

Each LLNL employee assigned to the Waste Storage Facilities is required to read and understand the applicable standard operating procedures, FSPs, and/or IWS/SPs for those activities with which the employee is involved. These procedures and plans are maintained as part of the operating record. FSPs and IWS/SPs are available for inspection and review from RHWM. Procedures are available from the Facilities, Safety, and Compliance Group in the RHWM Division.

Trained personnel perform all waste management activities and respond to emergency incidents at the Waste Storage Facilities. Training includes annual and refresher training as well as on-the-job training in special skills or knowledge areas. RHWM workers handling hazardous and radioactive materials receive extensive training in areas such as waste generation, certification, and transportation.

9.4 Radioactive and Hazardous Waste Streams or Sources

The waste types associated with the Waste Storage Facilities and the safety analyses of these materials are presented in Chapter 3, “Hazard and Accident Analysis,” and in Chapter 2, “Facility Description.” RHWM wastes were identified from the 2005 LLNL EIS (DOE 2005). Appendices A and B of the EIS quantify waste generation for LLNL, and the reader is referred there for further detail. Specific information on the types of hazardous and mixed wastes managed in the Waste Storage Facilities can be found in the Operation Plan (LLNL latest revision-d).

9.4.1 Waste Management Process

This section summarizes the overall waste management plan, including the management policy or philosophy, at the Waste Storage Facilities. Included in the discussion is a summary of administrative and operational practices important to effective management of each of the waste types (e.g., waste segregation).

RHWM Waste Storage Facilities Management Policy and Philosophy

Waste generated at the Waste Storage Facilities goes through the same process of identification, characterization, and labeling as wastes entering the Waste Storage Facilities from other facilities at

LLNL. Waste is segregated into separate containers according to compatibility and opportunities for recycling. The waste name, identifying constituents, characteristics, and any radionuclides in the waste in each container are recorded on a waste label attached to that container.

RHWM workers complete a waste disposal requisition (WDR) for waste generated at LLNL Site 200 and Site 300. The WDR is used to document information about the waste in a specific waste container. The WDR information is entered into a database management system that is maintained by RHWM for record keeping and retrieval. Each WDR is uniquely numbered to facilitate tracking through the computerized database. Subsequent management and treatment information is appended to the database to provide a complete disposition record of the waste stream. Once the waste is accepted, RHWM personnel determine whether the waste is appropriate for onsite treatment, storage, or offsite disposition.

Administrative and Operational Practices

Operations and activities in the Waste Storage Facilities are required to comply with the facility-specific FSP. FSPs implement policies and programs specified in LLNL's *ES&H Manual* and safety basis requirements. An Integration Work Sheet with a Safety Plan addendum (IWS/SP) is written as required for activities not described in the FSP. Operations and activities related to hazardous and mixed wastes are, in addition, required to comply with the DTSC Hazardous Waste Facility Permit, including the Operation Plan (LLNL latest revision-d).

9.4.2 Waste Sources and Characteristics

Wastes may be generated at the Waste Storage Facilities as a result of treatment, sampling, handling containers, maintenance, cleanup of spills, and other activities. Chapters 2 and 3 of this document include discussions of activities and operations in the Waste Storage Facilities. These chapters include descriptions of waste storage and appropriate waste handling in the Waste Storage Facilities.

9.4.3 Waste-Handling or Waste-Treatment Systems

Chapters 2 and 3 of this document include discussions of operations and activities in the Waste Storage Facilities. These chapters include descriptions of waste handling and waste treatment in the Waste Storage Facilities.

9.5 References

DOE (2005). Final Site-wide Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement, DOE/EIS-0348, DOE/EIS-0236-S3, March 2005.

LLNL (latest revision-a), Environment, Safety, and Health Manual, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

LLNL (latest revision-b), LLNL Radioactive Waste Program Certification and Quality Assurance Plan, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-148488, latest revision.

LLNL (latest revision-c), Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-116655, latest revision.

LLNL (latest revision-d), Operation Plan for Hazardous Waste Treatment and Storage Facilities, Livermore Site. Lawrence Livermore National Laboratory, Livermore, CA, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007

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CHAPTER 10
INITIAL TESTING, IN-SERVICE SURVEILLANCE, AND MAINTENANCE

10.1 Introduction

This chapter discusses testing, surveillance, and maintenance programs as they relate to facility safety in the Waste Storage Facilities. Essential features of the in-service test and inspection program also are addressed.

10.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for these facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 440.1A	Worker Protection Management for DOE Federal and Contractor Employees

10.3 Initial Testing Program

Initial testing or inspection for the Waste Storage Facilities consists of acceptance testing per design specifications and walkthroughs. Testing or inspections have been performed on the following equipment related to safety:

- Foam fire protection system to meet NFPA 11, *Standard for Low-, Medium-, and High-Expansion Foam*, and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.
- Personnel doors to meet NFPA 101, *Life Safety Code*.
- Fire sprinkler systems to meet NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*.
- Fire alarm systems to meet NFPA 72, *National Fire Alarm Code*.
- Emergency voice alarm (EVA) system to meet NFPA 72.

10.4 In-Service Inspection & Test Program

An in-service inspection & test program is established, implemented, and maintained to ensure the integrity of the Design Features described in Section 5.6. Inspections and tests are performed by qualified personnel. The in-service inspection & testing of safety significant SSCs (e.g., TRU waste containers, building structures) is discussed in Chapter 4.

Fire alarms, fire suppression systems, and fire extinguishers are inspected, tested, and maintained periodically for operational readiness. Hazard Control fire protection professionals, Emergency Management, and Plant Engineering also conduct periodic surveillances of fire suppression systems in accordance with applicable NFPA requirements.

10.5 Maintenance Program

LLNL has a maintenance program in effect that is described in the *ES&H Manual* (LLNL latest revision-a). The program incorporates applicable regulations and information from DOE Order 4330.4B, *Maintenance Management Programs* (DOE 1994), as well as self-assessments of LLNL maintenance organizations and previous audits. DOE Order 433.1, *Maintenance Management Program for DOE Nuclear Facilities* (DOE 2001), is replacing DOE Order 4330.4B, and is being implemented by LLNL. The RHWM maintenance program has been updated to meet DOE Order 433.1.

ES&H Manual Document 52.1, “LLNL Maintenance Implementation Plan for Nonreactor Nuclear Facilities”. Specific implementing details are found in RHWM-specific documents, such as the RHWM Maintenance Manual (LLNL latest revision-b). RHWM is responsible for maintaining SSCs and delineating requirements, including frequency of maintenance, calibration, and performance. The maintenance plan addresses the implementation of facility safety and operability and ensures that the capital investment in buildings and equipment is protected.

The graded approach to maintenance takes into account the potential for equipment failure on the following items, in order of importance: the public, laboratory workers, the environment, security and safeguards, and the Laboratory mission. A scale is used to rate anticipated results of the worst credible failure. Each structure, system, or component is assigned a risk rating. Areas and/or treatment units in the facilities are assigned a category (1 through 4) that corresponds to the highest risk rating for any structure, system, or component inside the area. The graded approach matches the category with the level of maintenance.

Category 1 is the most rigorous maintenance program, designed to emphasize reliability and minimize the probability of failure. Category 4 addresses maintenance limited to fixing broken items plus recurring activities, such as lubrication or cleaning. Safety-related systems in the Waste Storage Facilities have assigned risk categories, and the maintenance program is in accordance with the LLNL Maintenance Implementation Plan.

LLNL’s overall real property and installed equipment maintenance plan is referred to as the Critical Facilities Maintenance Program. This program is administered by the central maintenance organization. The RHWM Division administers the personal property and programmatic equipment maintenance program. Other LLNL organizations that assist RHWM in maintenance are Plant Engineering, Mechanical Engineering, Motor Pool, and Hazard Control. RHWM maintenance procedures incorporate the Waste Storage Facilities designs and operations.

The Facility and Maintenance Management Division of the Plant Engineering Department and/or Emergency Management provide the personnel for maintenance of the sprinklers. Journeyman plumbers are trained in sprinkler piping and operations. Journeyman electricians are trained in alarm system operation and maintenance.

10.6 References

DOE (1994), *Maintenance Management Program*, DOE Order 4330.4B, U.S. Department of Energy, Washington, DC, February 10, 1994.

DOE (2001), *Maintenance Management Program for DOE Nuclear Facilities*, DOE Order 433.1, U.S. Department of Energy, Washington, DC, June 1, 2001.

LLNL (latest revision-a), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

LLNL (latest revision-b), *RHWM Maintenance Manual*, Lawrence Livermore National Laboratory, Livermore, CA, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 11
OPERATIONAL SAFETY

11.1 Introduction

This chapter describes the operational safety provisions, including the fire protection program, as they relate to the RHWM Waste Storage Facilities. Provisions in this information will satisfy the requirements of DOE-STD-3009-94, Change Notice 3. Operational safety and the fire protection program ensure that the Waste Storage Facilities can be operated without undue risk to the health and safety of facility workers, other onsite employees, or individuals at the site boundary. The general aspects of operational safety that are applicable to the facility are presented in Section 11.3, "Conduct of Operations." Conduct of operations for the Waste Storage Facilities follows the guidance specified by DOE Order 5480.19, Change Notice 2 (DOE 2001), *Conduct of Operations Requirements for DOE Facilities.* Chapter 11 includes the basis for the conduct of operations program and the fire protection program.

11.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 5480.19, Change Notice 2	Conduct of Operations Requirements for DOE Facilities

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
29 CFR 1910	Occupational Safety and Health Standards
29 CFR 1926	Safety And Health Regulations For Construction

11.3 Conduct of Operations

To ensure compliance with Chapter 1 of DOE Order 5480.19, Change Notice 2, the Waste Storage Facilities operate in accordance with *ES&H Manual* Document 3.5, "Conduct of Operations for LLNL Facilities" (LLNL latest revision-a). Document 3.5 provides requirements and guidelines for the departmental elements to be used in developing directives, plans, and procedures relating to the conduct of operations at the Waste Storage Facilities. The practices and implementation of the programs described in this document provide consistent and auditable requirements, standards, and responsibilities for Waste Storage Facilities operations. Specific topical areas from DOE 5480.19 on conduct of operations that are considered in the Waste Storage Facilities are as follows:

- **Operations Organization Administration.** The RHWM facility manager, line manager, supervisors, and project leaders operating within the Waste Storage Facilities are responsible for ensuring the safety of operations and that an acceptable level of performance is achieved. The RHWM project leaders and group leaders are responsible for accomplishing division waste handling, processing and shipping goals, and the RHWM supervisors are responsible for directing day-to-day activities of employees and keeping management informed of operating problems and achievements. More information is provided in Chapter 17.
- **Shift Routines and Operating Practices.** Operations personnel adhere to the safety practices in the facility safety plans, conduct routine facility and equipment inspections and promptly notify supervisors of any unexpected situations. Personnel protection practices are followed to maintain personnel exposure as low as reasonable achievable to radiation, chemicals, toxic materials, or other personnel hazards. Through line management, the Waste Storage Facilities operations supervisor directs overall operations of the facility and ensures that only trained personnel are working in the facility.
- **Communications.** The Waste Storage Facilities provide adequate and reliable communication capabilities during routine and emergency conditions. The Waste Storage Facilities communication systems include telephones, emergency voice alarm (EVA) systems, personnel beepers, radios, and audible and visual alarms. Employees are instructed in the proper use of facility-specific communication devices. In addition, communications include fire pull stations that alert the onsite Fire Department Emergency Dispatch. A description of safety support systems is provided in Chapter 2.
- **Control of On-the-Job (On-shift) Training.** Waste Storage Facilities employees who are new to an area may have a thorough technical background and a theoretical understanding of an operation, but on-the-job training (OJT) may still be required to ensure they understand specific details of an operation. Work conducted by personnel under instruction is carefully supervised to avoid errors that could have significant impact on safety or operations. OJT is conducted so that the trainee satisfactorily completes all of the required training objectives and receives maximum learning benefit from the experience. The training of workers meets the requirements of 29 CFR 1910.120 HAZWOPER. A description of training for workers is provided in Chapter 12, "Procedures and Training."
- **Investigation of Abnormal Events.** Using the guidance provided in the *ES&H Manual* Volume I, Part 4, "Feedback and Improvement," the RHWM facility manager is responsible for identifying abnormal events that require analysis. This document provides guidance for investigating abnormal events.
- **Notifications.** Employees or project leaders notify their line management of events that could affect the health and safety of the public or endanger the health and safety of employees. Line management is then responsible for notifying appropriate LLNL and DOE personnel, and other agencies, of these events. *ES&H Manual* Document 4.5, "Incidents--Notification, Analysis, and Reporting," ensures the uniformity, efficiency, and thoroughness of such notifications consistent with DOE Order 231.1A.
- **Controlling Equipment and System Status.** The status of Waste Storage Facilities equipment is monitored. Systems or operations are controlled so that operations proceed according to specifications. Significant Waste Storage Facilities equipment is discussed in Chapter 2.

- **Lockouts and Tagouts.** Lockout and tagout is a proven procedure for ensuring that employees do not cause the unintentional release of energy, such as electrical or mechanical, to themselves or others, when working on or around equipment capable of causing harm. It is imperative that individuals working on or around potential stored energy sources at the Waste Storage Facilities observe LLNL's lockout and tagout policies and procedures. The Waste Storage Facilities operate in accordance with *ES&H Manual* Document 12.6, "LLNL Lockout/Tagout Program," which provides guidance on this subject.

- **Independent Verification.** Independent verification is the act of checking to ensure that essential components such as valves, switches, circuit breakers, and other items are positioned to ensure proper functionality as established. Such verification recognizes the human element of component operation, that is, that any employee, no matter how proficient, can make a mistake and misposition valves, switches, circuit breakers, or other items. The concept of independent verification is incorporated into written procedures for the Waste Storage Facilities, as applicable.

- **Logkeeping.** Formal records or logbooks are maintained for those operations that can have significant impact on health, safety, or the environment, or significant impact to programs. The records contain enough information so they can be used to track the history of various situations or pieces of equipment, or to document occurrences within the facility.

- **Operations Turnover.** Shift personnel should be aware of the current conditions in the Waste Storage Facilities so that they can perform their duties in a safe manner. Therefore, it is important that employees report changes and other relevant information that occur during their shift. However, the Waste Storage Facilities operations typically operate only during the normal 8- to 10-hour day shift. Off-shift work is occasionally conducted and may include the performance of inspections.

- **Operations Aspects of Facility Chemistry and Unique Processes.** The RHWM facility manager or group leaders are responsible for identifying and monitoring those operating parameters that, if out of range, could impact health, safety, or the environment. There are no operating parameters in the Waste Storage Facilities that require indirect monitoring.

- **Required Reading.** LLNL's safety policies and procedures are documented in a variety of manuals, including the *ES&H Manual*, FSPs, Documented Safety Analyses, nonnuclear safety basis, Technical Safety Requirements, and IWS/SPs. The RHWM Division has a required reading program, which is specified in the *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL latest revision-b).

- **Timely Orders and Instructions to Operators/Workers.** Instructions that are important to health, safety, or the environment are communicated to the Waste Storage Facilities employees. Instructions are provided in safety and operating procedures, employee instructions, operator aids, request forms, and LLNL notices.

- **Operating Procedures for Equipment and Systems.** Waste Storage Facilities procedures are written instructions that give employees directions on how to conduct specific operations or operate specific systems or pieces of equipment during normal, postulated off-normal, and emergency conditions. The procedures are written for operations that could significantly impact health, safety, the environment, or the program. The procedures are outlined in Chapter 12, "Procedures and Training."

- **Operator-Aid Postings.** "Operator aids" are technical postings, other than formal procedures, rules, instructions, or the like, that assist employees in accomplishing specific tasks. Required postings (those that are not operator aids) include radiation area signs, material balance sheets, and evacuation assembly point postings. Operator aids provide an important function in the safe operation of a facility. Postings in the Waste Storage Facilities reflect the most current information available.
- **Equipment and Piping Labeling.** Equipment labeling is required by Occupational Safety and Health Administration (OSHA) regulations. Equipment and piping is consistently labeled in the Waste Storage Facilities so that maintenance and modifications can be safely conducted.

11.4 Fire Protection

11.4.1 Fire Hazards

This section provides an overview of the Waste Storage Facilities fire hazards in terms of overall combustible loading in proximity to hazardous materials being stored at the Waste Storage Facilities. Explosive materials (e.g., those materials used in the fabrication of an explosive device) are not stored in the Waste Storage Facilities; thus, explosion criteria are not applicable. Fire hazards at the Waste Storage Facilities consist of fuel sources and ignition sources. The Fire Hazards Analyses (FHAs) for the Waste Storage Facilities (LLNL 2007b, LLNL 2007c, LLNL 2007d, LLNL 2007e) provide more information on fire protection issues at the Waste Storage Facilities.

Fuel Sources

The primary fuel sources identified within the facilities and proximal to the hazardous material inventory are as follows:

- **Combustible Contents of Non-Metal Waste Containers**. Combustible waste within the waste inventory primarily consists of paper, cloth, plastic, and other ordinary combustible materials. Some of the combustible materials may also be co-contaminated with organic solvents or Class 1 oxidizers, e.g., nitrate salts or cellulosic materials. Class 1 oxidizers slightly increase the burning rate but do not cause spontaneous ignition when they come in contact with combustible materials according to NFPA 430, *Code for the Storage of Liquid and Solid Oxidizers*. Wastes may include flammable or combustible liquids stored in compatible closed containers.
- **Combustible Packaging and Pallets**. All TRU waste is packaged in steel containers. LLW and hazardous waste may be stored in a variety of containers including metal containers or combustible packaging such as plastic drums and bags, plastic tanks, wood crates, and fiber boxes. Waste other than TRU waste may be stored on combustible pallets. Combustible materials in Waste Storage Facilities that store TRU waste are limited by the combustible loading controls described in Section 11.4.3. High density polyethylene (HDPE) pallets that are designed to contain minor spills are used in the Waste Storage Facilities. While HDPE has a high heat of combustion, approximately 43 MJ/kg, the 1% thermal decomposition temperature and flashpoint exceed 540°K (510°F, SFPE 1995) and 616°K (650°F), respectively. The combustion characteristics of HDPE indicate that plastic pallets used for minor spill containment are difficult to ignite and, once ignited, difficult to sustain.

- **Propane**. Many of the forklifts used to convey waste containers inside and outside the facilities are powered by liquefied propane gas (LPG). Propane forklifts with 15- to 35-lb fuel tanks represent a significant source of flammable gases. Refueling is performed outdoors by changing out the forklift LPG tank. Nevertheless, LPG inside a forklift fuel tank will flash to vapor if released to the atmosphere, and, therefore, represents a flammable gas hazard.
- **Liquid Fuels**. The most common, significant fuel source is a flammable/combustible liquid spill from a vehicle (i.e., fuel or hydraulic fluid). Vehicles include cars, forklifts, and various sizes of trucks, ranging from small utility vehicles with 10 to 20 gal of gasoline or diesel fuel, up through trucks with supplemental fuel supplies or an occasional large tractor-trailer truck with up to 80 gal of fuel. The fuel system on trucks and cars satisfies applicable Department of Transportation (DOT) requirements. Incidental quantities of liquid fuels may also be in the facilities for other activities. There is also drummed flammable liquid waste stored in designated locations.
- **Hydraulic Fluid**. The fluid used to power the hydraulic system of forklifts has a flash point greater than 200°C (390°F) with a limited volume of less than 90 liters (20 gal). This hydraulic fluid is a Class IIIB combustible liquid in accordance with NFPA 30, *Flammable and Combustible Liquids Code*.
- **Cleaning Solvents**. Small amounts of cleaning solvents may be present, and are properly stored according to *ES&H Manual*, Document 14.1, “LLNL Chemical Safety Management Program.”
- **Chemicals**. Chemicals may be present and are properly stored according to *ES&H Manual*, Document 14.1, “LLNL Chemical Safety Management Program.”
- **Combustible Building Construction Materials**. The Waste Storage Facilities are generally constructed of noncombustible materials.

Ignition Sources

The following potential ignition sources that may exist inside or outside the Waste Storage Facilities were evaluated in the process hazard analysis (PrHA) and were found to be adequately controlled. The means to minimize or control these sources are discussed, as appropriate.

- **Vehicles**. Engine heat from trucks and vehicles operating near the Waste Storage Facilities presents a potential ignition source for the fuel sources described above. The PrHA considered several vehicle accidents, including forklift accidents, that result in a fire and waste burning.
- **Forklifts**. Engine heat from forklifts used during waste container handling operations presents a potential ignition source for the combustible waste being conveyed. However, container handling places waste containers away from the forklift engine, and because TRU waste is packaged within metal waste containers, engine heat is a highly unlikely ignition source for the combustible contents of TRU waste containers.
- **Electrical Fault**. Facility electrical systems were designed in accordance with NFPA 70, *National Electric Code*. Electrical wiring and devices in the vicinity of operations where fire or explosion hazards may exist due to flammable gases or vapors are rated as suitable in accordance with Chapter 5 of NFPA 70. All electrical wiring within the waste storage facilities is routed within conduit. In addition, major electrical equipment is installed according to PC-2 seismic criteria.

- **Lightning**. The Livermore Valley rarely experiences severe weather. Thunderstorms typically occur fewer than 10 days per year and are not intense. Thus, the Waste Storage Facilities are not equipped with lightning protection air terminals. The buildings, however, are grounded.
- **Refueling Fire**. A fire associated with gasoline or diesel refueling operations, or during forklift LPG tank replacement, represents a potential ignition source for exposed combustibles. Similarly, refueling operations conducted proximal to the Waste Storage Facilities could expose the structures. Refueling operations are typically conducted at the motor pool away from the Waste Storage Facilities.
- **Aircraft Crash**. There is a probability of a small aircraft crash in the Waste Storage Facilities as discussed in Chapter 3. The onsite Fire Department will respond to such an event. Many of the Waste Storage Facilities have fire sprinklers that would activate, where the system is not damaged. Supplemental water can be provided from nearby hydrants (see Section 11.4.4).
- **Welding**. Occasional welding, using either electrical arc or hot flame (oxyacetylene or MAAP gas), may be required to maintain important building systems. LLNL uses a permit system described in *ES&H Manual* Document 2.2, "Managing ES&H for LLNL Work." Before welding could be performed, a Hot Work Permit must be issued by the Emergency Management to ensure personnel who perform welding, soldering, and other hot-work operations with a high fire potential are aware of and protected from hazards.
- **Wildfire**. The area north of B696 is asphalt paving for about 20 feet. On the north side of the asphalt is a row of small trees, about 20 feet tall, beyond which is an open field buffer zone, owned by LLNL, and kept from accumulating weeds by seasonal mowing. Although wildfire could occur in open grassy areas near facilities or in forested areas further away, the area north of B696 is maintained free of excess weeds and grass. The exposure threat of a wildfire is minimal. Areas adjacent to all other Waste Storage Facilities are paved or lawn. Trees north of B696 and adjacent to Area 625 are periodically trimmed and maintained to reduce fire exposure to storage areas/buildings.

The estimated combustible loading in the various Waste Storage Facilities areas is low. Combustible materials are limited to the quantity required for current needs and are separated from ignition sources. Protection of the facilities is provided by automatic fire suppression systems, portable fire extinguishers, and fire-rated construction, as described in the FHAs. The hazard analysis documented in Chapter 3 addresses fire hazards particular to the Waste Storage Facilities.

Fire Hazards Analyses

FHAs have been prepared for Tent 6197, Tent 6198, B625, B693 and B693 Annex, and B696 of the Waste Storage Facilities (2007b, LLNL 2007c, LLNL 2007d, LLNL 2007e). The conclusion of each of these FHAs is that the facility meets the fire protection objectives and criteria outlined in Section 4.2 of DOE Order 420.1A (DOE 2002), qualifying it as an Improved Risk Facility.

11.4.2 Fire Protection Program and Organization

In conformance with DOE Order 420.1A and the LLNL *ES&H Manual*, the fire safety program at the Waste Storage Facilities includes provisions for:

- Minimizing the potential for occurrence of a fire or related event in the Waste Storage Facilities.
- Ensuring that fire does not cause an unacceptable onsite or offsite release of hazardous or radioactive material that will threaten the health and safety of employees, the public, or the environment.
- Providing an acceptable degree of life safety to LLNL and contractor personnel and the public from fire in the Waste Storage Facilities.
- Ensuring that the Waste Storage Facilities operations will not suffer unacceptable delays as a result of fire and related hazards.
- Ensuring that property damage to the Waste Storage Facilities from fire and related events does not exceed defined limits in *ES&H Manual* Document 22.5, "Fire."

LLNL maintains a large staff of emergency response personnel, including an onsite Fire Department, ambulance services, security services, and a fully staffed medical facility. In addition, a communications system is maintained specifically for emergency control purposes. Fire alarms at the Waste Storage Facilities annunciate at the LLNL Fire Dispatch Center (B313), where personnel, in turn, transmit alarms over the EVA within the affected building.

The LLNL fire protection program is implemented through three organizations: Emergency Management, Plant Engineering, and ES&H Teams. Emergency Management—the onsite Fire Department—is responsible for initial response to and investigation of all life-threatening and property-loss emergencies on or adjacent to LLNL property. This organization inspects and tests selected fire protection equipment. This division also provides fire protection engineering leadership to ES&H Team members. The subject matter expert (SME) for Fire Protection Engineering acts as the Fire Protection Program Manager and is also the LLNL Fire Marshal. Five ES&H Teams provide environment, safety, and health support to the various LLNL programs. Each ES&H team has at least one assigned, qualified fire protection engineer who provides fire protection engineering support. The fire protection engineer performs periodic facility walkthroughs to observe the physical conditions of the facilities and their fire protection features. Plans for new or revised fire protection systems and features for the Waste Storage Facilities must be reviewed and approved by the ES&H Team 1 Fire Protection Engineer prior to start of work. Fire extinguishing system acceptance tests and inspections must be witnessed by the ES&H Team 1 Fire Protection Engineer prior to occupancy.

The Plant Engineering Department and Emergency Management have the primary responsibility for testing and maintaining LLNL's fire protection and detection systems and utilities. They also have primary responsibility for portable fire extinguisher testing and maintenance.

The RHWM Self-Help Plan (LLNL latest revision-c) and the Contingency Plan for RHWM facilities (LLNL latest revision-d) outline the emergency program and actions to be taken by RHWM personnel responding to fires and other potential accidents at the Waste Storage Facilities.

11.4.3 Combustible-Loading Control

Combustible loading in the Waste Storage Facilities is controlled as a function of the LLNL fire protection program. RHWM implements measures to minimize and control the use of combustible materials at the Waste Storage Facilities and to prevent the accumulation of unnecessary combustibles. In addition, only waste in metal containers and on metal pallets is allowed in TRU waste storage areas.

Table 7-5A in the *Fire Protection Handbook*, 18th edition (NFPA 1997), limits allowable combustibles in accordance with the fire-resistive rating of the partitions of a compartment in a building. The combustible loading limit is established to preclude the potential for fire propagation. The allowable combustible loading is 5 psf per each half-hour fire-resistive rating of a partition or a wall that separates the compartments. For compartments separated by a one-hour fire-rated partition, such as B696R Room 1010 and 1011, the combustible loading allowed by Table 7-5A in the *Fire Protection Handbook*, 18th edition, is 10 psf. For conservatism in a TRU waste storage facility, a lower combustible loading limit of 7 psf is conservatively established, which is consistent with the definition of light fire loading discussed in NPFA 80A, *Recommended Practice for Protection of Buildings from Exterior Fire Exposures*. Waste containerized in metal packaging is excluded from the combustible loading control.

In addition, for B696, the combustible loading limit is a critical element for protection of the B696S/B696R partition in the event of a fire in B696R. The 7 psf combustible loading limit in B696R Room 1010 helps limit the severity of a fire such that the fire is not expected to challenge the partition or partition-roof interface in a manner that would allow the fire to circumvent the partition or propagate from B696R to B696S.

Implementation of the combustible-loading control measures includes, but is not limited to, the following activities:

- Housekeeping is inspected at least monthly by a trained staff member to ensure that equipment, materials, and stored wastes are orderly.
- The combustible loading limit of an average of 7 pounds per square foot (psf) of equivalent ordinary combustibles is established in fire areas storing TRU waste, excluding waste containerized in metal packaging.
- Non-combustible or fire-retardant materials are used whenever practical.
- TRU waste is stored on non-combustible pallets.
- Only waste in metal containers and on non-combustible pallets is allowed to be stored in TRU waste storage areas.
- Combustible waste incidental to operations is collected in covered metal containers.
- Allowance for only incidental quantities of flammable or combustible liquids (less than the exempt quantities for the occupancy type of the facility), except in designated flammable/combustible liquid storage areas. This does not prohibit the use of propane, diesel, gasoline, or electric powered forklifts.
- Grass and brush are clear-cut and removed from the vicinity of buildings and waste storage areas.
- A 20-ft exclusion zone is maintained between the DWTF Storage Area and the B695 Segment of DWTF, except between B696S and B696R, which are separated by a fire-resistive partition. In addition, the exclusion zone is expanded between adjacent roll-up doors in B696 near the segment boundary. This prevents fire from impacting both segments through adjacent roll-up doors.

11.4.4 Fire Fighting Capabilities

A detailed discussion of fire fighting capabilities at LLNL is provided in the *Lawrence Livermore National Laboratory Emergency Plan* (LLNL latest revision-e). The onsite Fire Department response schedule to emergencies is described in Emergency Management policy number 1200, *Response Schedule*. Fire Department response time for the main Livermore site is expected to be less than five minutes to any facility. Normal response to an automatic alarm is one engine with a crew of four; further equipment and/or personnel are available from the onsite Fire Department as necessary. Additional fire fighting support is available through mutual aid from outside fire agencies.

A detailed description of available fire fighting equipment, fire response procedures, basic training, personnel qualifications for firefighters, and special precautions taken for fire fighting in radiological and hazardous chemical environments is provided in LLNL's *Fire Protection Program Manual* (LLNL latest revision-f).

The Contingency Plan developed for the RHWM facilities (LLNL latest revision-d) provides an overview of the fire protection available at the Waste Storage Facilities to detect fires, alert personnel to fire emergencies, suppress fire, and minimize fire spread. Portable fire extinguishers and fire hydrants are available at all Waste Storage Facilities.

Automatic Fire-Suppression Systems

B625 and B696R have fire sprinkler systems meeting NFPA 13 for Ordinary Hazard occupancies. All are wet pipe systems

Building 693 has a fire sprinkler system meeting NFPA 13 for Ordinary Hazard Group 2, except that Room 1000 and 1014 which are Extra Hazard Group 1. B693 Room 1000 has an automatic high-expansion foam fire extinguishing system that is the primary fire protection provided for flammable waste storage. This system is triggered either by rate compensated heat detectors, or by manual pull stations, and should activate prior to the fire sprinklers, greatly reducing the quantity of water that might be discharged on a fire.

Sprinkler flows are monitored to automatically initiate a fire alarm at the LLNL Fire Dispatch Center. Each of these buildings has some capability to retain fire water discharged from the automatic sprinkler systems. Further details regarding the fire suppression systems and fire water retention are provided in the FHAs. If a fire suppression system is impaired, compensatory measures (in compliance with NFPA 25) will be put in place during hot work operations and forklift container movements in the facility when TRU waste is present in the fire area.

A general LLNL requirement mandates that contaminated liquid runoff from fire fighting operations should be prevented from leaving the site. LLNL firefighters are aware of the requirement and, when possible, they prevent fire fighting water from entering storm drains. The Sewer Diversion Facility is designed to prevent hazardous materials from being carried offsite from the Laboratory's sanitary sewer system, including fire fighting water entering the waste stream from a building's sewer system or floor drains.

Fire Detection and Alarms

B625, B696R, and B693 are protected by presignal fire alarm systems. The fire alarm system is activated when water discharges from a fused sprinkler or when a manual fire alarm pull station (in selected locations) or heat detector (in selected locations) is activated. The fire alarm control panel transmits the alarm to the LLNL Fire Dispatch Center, automatically summoning the onsite Fire Department. The system does not automatically initiate audible and visual building EVAs. The emergency dispatcher must manually initiate building EVAs.

Fire Extinguishers

Appropriate types and sizes of fire extinguishers are placed throughout the Waste Storage Facilities and maintained in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. Additional fire extinguishers are located where specific fire hazards are present.

Water Supply and Fire Hydrants

Water is supplied to the main Livermore site from three, elevated, 500,000-gallon (each), steel tanks located on the Sandia National Laboratories Livermore site, approximately one mile south of the Laboratory. Fire protection and domestic water is supplied to the grid system at LLNL through one 14-in and one 16-in water main connected into a 14-in water main on the south side of the LLNL grid. The LLNL grid consists of mains of varying size, and the minimum main size is 8 in. In addition to primary supply reservoirs, secondary connections are provided to local municipal water mains on both the west and north sides of the Laboratory. An additional connection to the 27-in, Zone *7* water main on the Laboratory's north side is pumped into the Laboratory's water distribution system through approved fire pumps, as needed. With all available water supplies considered, the total available water flow (to depletion) at LLNL is 8,900 gpm for 5 hours and 7,476 gpm for 7 hours.

Multiple fire hydrants are located in the vicinity of the Waste Storage Facilities as part of the LLNL fire protection system. The flow capabilities of the hydrants protecting the Waste Storage Facilities are adequate to fight expected fires as detailed in the FHAs. Hydrant flow tests are conducted by the onsite Fire Department. Records of the tests and water flow information are available at the Emergency Management Division office. Outage of fire protection water for non-routine maintenance complies with NFPA 25.

Other Fire Controls

Fire breaks, in the form of asphalt-paved open spaces or lawns, surround the Area 625 and DWTF facilities. Furthermore, a 20-ft firebreak marked "Keep Clear" between the DWTF Storage Area and the B695 Segment of DWTF has been established. The Waste Storage Facilities have marked fire lanes as required by LLNL. The locations of individual fire rated partitions within Waste Storage Facilities buildings are described in the FHAs and in Chapter 2, "Facility Description."

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, diamond-shaped placards are provided throughout RHWM facilities. The placards indicate the maximum hazard in each category (health, fire, reactivity, and special warnings) associated with the types of material in the facility and indicate the worst-case condition that an emergency responder can expect to encounter at the facility.

A variety of heavy equipment is available from Plant Engineering to assist in a fire emergency. The equipment includes compressors, cranes, cutting torches, forklifts, generators, pumps, scrapers, and bulldozers. Emergency equipment is maintained regularly to ensure that it is operational at all times.

Fire Response Procedures

The RHWM Self-Help Plan and the Contingency Plan identify personnel responsibilities, emergency equipment, and required actions necessary to mitigate fires within the Waste Storage Facilities. These plans also specifically define the types of emergencies that must be mitigated by the onsite Fire Department and those that may be remedied by RHWM personnel. The types of emergencies and responses are outlined in Chapter 15, “Emergency Preparedness Plan.” RHWM personnel may respond to a small incident without notifying the onsite Fire Department.

Basic Training and Personnel Qualifications

RHWM personnel are trained in appropriate responses to potential emergencies, such as fires, including calling the onsite Fire Department and evacuating as necessary. The training is outlined in the FSPs and in *ES&H Manual* Document 40.1, “LLNL Training Program Manual.” Basic training and qualifications are provided in Policy 1130, “Minimum Professional Standards for Fire Fighters, Fire Officers, and Chief Officers,” of the LLNL Fire Department Policies and Procedures Manual.

The requirements of 29 CFR 1910.120 for emergency responders, including the onsite Fire Department, to a fire or explosion at the Waste Storage Facilities are implemented through *ES&H Manual* Document 40.1, “LLNL Training Program Manual.”

Special Precautions

Special precautions are needed for fighting fires in radiological and hazardous chemical environments. Protection of firefighters at LLNL in radiological environments is outlined in *ES&H Manual* Document 22.6, “Exposure to Radiation in an Emergency.” Special precautions are also described in documents and procedures provided in Policy 1130, “Minimum Professional Standards for Fire Fighters, Fire Officers, and Chief Officers,” of the LLNL Fire Department Policies and Procedures Manual.

11.4.5 Fire-Fighting-Readiness Assurance

The onsite Fire Department conducts periodic fire protection inspections of facilities. In addition, the RHWM Division has a combustible-loading control program that includes inspections of the Waste Storage Facilities to keep them free from unnecessary combustibles.

RHWM personnel participate in LLNL site-wide Self Help drills annually. LLNL conducts a coordinated program of these drills and exercises to provide emergency-response training and to establish a method for evaluating the response capability and readiness. Drills are designed to develop and maintain personnel emergency-response skills. They are conducted separately by each emergency response organization (ERO) and reflect the organization’s specific training needs, which have been discovered during prior drills.

The Emergency Management Exercise Program is an annual, full-participation exercise based on rotating scenarios, such as a natural disaster, a security incident, or hazardous material incidents. The scenarios are designed to test the operational capability of individual organizations. The drills are evaluated for each exercise, and lessons learned are incorporated into emergency plans and procedures. Drills and exercises are discussed in the *Lawrence Livermore National Laboratory Emergency Plan*.

The process for classification and notification of accidents at the Waste Storage Facilities is outlined in the *Lawrence Livermore National Laboratory Emergency Plan*. Internal reporting at the Waste Storage Facilities requires employees to notify the Storage and Disposal Group Leader, or designee, of all release incidents (large or small), and the onsite Fire Department of all large incident releases, fires, or other emergencies. The Storage and Disposal Group Leader, or designee, gathers preliminary information and then must immediately notify the facility manager and the Hazard Control ES&H Team. Records of fire protection system testing, inspection, and maintenance shall be prepared and retained based on the requirements of NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems*, and in accordance with LLNL procedures.

11.5 References

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LLNL (2007b), *Fire Hazards Analysis B6198 6198*, Lawrence Livermore National Laboratory, Livermore, CA, (September 2007).

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LLNL (latest revision-c), *Self-Help Plan Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA.

LLNL (latest revision-d), *Contingency Plan for Radioactive and Hazardous Waste Management Facilities: Area 612, Area 514, Building 233 CSU, and the Decontamination and Waste Treatment Facility*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-127066, latest revision.

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LLNL (latest revision-f), *Fire Protection Program Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-116646, latest revision.

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CHAPTER 12
PROCEDURES AND TRAINING

12.1 Introduction

This chapter addresses the processes by which the content of procedures and the training program are developed, verified, and validated at the Waste Storage Facilities.

12.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 5480.19, Change Notice 2	Conduct of Operations Requirements for DOE Facilities
DOE O 5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
40 CFR 264.16	Personnel Training

California Code of Regulations

22 CCR 66264.16	Personnel Training

12.3 Procedure Program

DOE Order 5480.19, Change Notice 2 (DOE 2001), requires that procedures be developed to provide specific direction for the operation of systems and equipment during normal, abnormal, and emergency conditions. The order includes technical-content development, verification, and validation requirements for procedures. The requirements of this order are implemented at the Waste Storage Facilities through the use of *ES&H Manual* Document 3.5, "Conduct of Operations for LLNL Facilities." This document requires that safety plans and operating procedures be developed to ensure that workers are properly trained regarding identified hazards and associated controls, and to provide workers directions on how to conduct specific operations or operate specific systems or pieces of equipment during normal, postulated off-normal, and emergency conditions for operations that could significantly impact health, safety, the environment, or the program.

The Radioactive and Hazardous Waste Management (RHWM) Division implements its programs and controls through procedures. Procedures are developed by RHWM to ensure that waste is managed in a manner that will protect human health and the environment and that the procedure contents will comply with all applicable regulatory requirements.

ES&H Manual Document 3.3, “Facility Safety Plans and Integration Work Sheets with Safety Plans,” governs the development of FSPs and IWS/SPs. Each FSP provides general facility safety policies and rules, identifies hazards and environmental concerns, and specifies the ES&H controls for long-term experiments, operations, and work performed in the facilities.

RHWM has a procedure that governs the development of RHWM administrative and standard operating procedures. This procedure meets the requirements of *ES&H Manual* Document 3.4, “Preparation of Work Procedures,” Document 3.5, “Conduct of Operations for LLNL Facilities,” and the *Radioactive and Hazardous Waste Management Division Quality Assurance Plan* (QAP) (LLNL latest revision-a).

12.3.1 Development of Procedures

Risk is the fundamental consideration in determining that procedures be developed for activities. Supervisors are responsible for making this determination and for directing the development of a procedure to ensure correct performance of an activity and to address safety concerns.

A technical subject-matter expert (or experts) is assigned to work with the technical writer/safety professional to provide input to the procedure. Procedures are written according to a standard format to ensure uniformity across the division.

The FSPs specify the responsibilities, hazards, policies, and controls for operations within the facilities. IWS/SPs contain the basic controls needed for safe operation beyond those contained in the *ES&H Manual* and applicable FSPs. The RHWM procedures cover specific administrative and technical activities at a more detailed level. These documents contain safety advice for a given activity, preoperational requirements, the assignment of responsibilities, instructional steps on how to perform the activity in a safe manner, specific record-keeping requirements, and other miscellaneous information associated with the operation.

Procedures are formally reviewed, verified, and validated. Draft procedures are submitted for formal review to management, various subject-matter experts, and ES&H safety professionals as applicable. All comments are resolved, and the documents are submitted for final signature review.

12.3.2 Maintenance of Procedures

Supervisors are responsible for ensuring that their staff is familiar with the latest FSPs and procedures pertinent to their operation. This responsibility is implemented through the RHWM reading program, OJT, classroom training, and general supervisory oversight. The RHWM FSPs and procedures are available on RHWM’s controlled document server.

The FSPs and IWS/SPs are controlled as outlined in *ES&H Manual* Document 3.3, “Facility Safety Plans and Integration Work Sheets with Safety Plans.” RHWM’s procedures are controlled in accordance with a RHWM document control procedure and are distributed by being posted on the controlled document server. Authorized versions of RHWM’s procedures are available only from the controlled document server or the RHWM Document Control Office files.

Procedures undergo periodic review to ensure that their contents still reflect current operations and comply with any ES&H regulations that may have been issued since the last review. FSPs are reviewed and updated at least triennially. If no changes are required, a memo to that effect is prepared and signed by the responsible individual. The memo is controlled and disseminated according to *ES&H Manual* Document 3.3, “Facility Safety Plans and Integration Work Sheets with Safety Plans.” Administrative procedures are reviewed and updated triennially, and standard operating procedures are reviewed and updated annually or triennially depending on the scope. If changes occur to an operation prior to the standard review time, it is the responsibility of the area supervisor to initiate the update of the procedure. The update may take place in the form of an addendum or a revision to the original FSP, an “immediate change implementation” to a procedure, or it may involve update and re-issuance of the actual document. Review, approval, and distribution requirements for issuing addenda and supplements are the same as those for the original procedure. During the next regular revision, addenda or supplements are incorporated, as necessary, into the original safety procedure. Changes to procedures are evaluated in accordance with Document 51.3, “LLNL Unreviewed Safety Question (USQ) Procedure,” in the *ES&H Manual*, as appropriate.

12.4 Training Program

RHWM follows requirements in DOE Order 5480.20A (DOE 1994), which specifies selection, qualification, and training requirements for personnel involved in the operation, maintenance, and technical support of DOE nuclear facilities. The training requirements of 29 CFR 1910.120, paragraph P, are implemented at the Waste Storage Facilities through *ES&H Manual* Document 40.1, “LLNL Training Program Manual.” The training of personnel in hazardous waste management procedures is also required by 22 CCR 66264.16 and is implemented through *ES&H Manual* Document 36.1, “Hazardous, Radioactive, and Biological Waste Management Requirements.”

The main purpose of the RHWM training program is to provide appropriate instructional support that will enable RHWM workers to develop and maintain competencies for successfully executing work assignments. *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” provides guidance for developing and managing individual directorate training programs. Guidance includes the following:

- Determining job categories, specific qualification requirements, and training requirements and responsibilities.
- Documenting training information.
- Qualifying course materials and instructors.
- Evaluating the training program.

The RHWM training program provides RHWM personnel with:

- Basic knowledge of regulatory requirements, hazards, and facility emergency response activities.
- Waste handling activities, including transportation of materials, tie-down methods, sampling activities, and general container handling.
- Instruction on specific duties and responsibilities relative to an individual’s hazardous, radioactive, or mixed waste activities.

- Waste management unit-specific instruction for hazardous waste treatment, storage, and offsite shipment for those RHWM personnel who perform hands-on hazardous waste management facility operations.
- Presently, licenses are issued to forklift drivers.

RHWM personnel receive both broad and specific training in hazardous and mixed waste regulations relative to their job duties and responsibilities, including emergency response activities, to reduce the risk from accidents. Training is provided by several different methods depending on the type of information and skills required for performing the task. The first type is classroom instruction, provided by an instructor in a lecture and discussion format. The second type is training and evaluation implemented through On-the Job Training (OJT) for specific operations. A third type is self paced reading and review of safety and procedural documents. A fourth type is E-learning which is delivered through computers and other multi-media technologies. In some cases a combination of these methods will be used to convey the information and then provide the trainee practical experience in performing the activity.

The goal of the LLNL training program is to ensure that all employees have the skills and knowledge to carry out their work assignments safely and effectively. The objectives of the LLNL training program are to determine and document training requirements, to document and make available appropriate training-related information, to ensure that the program is structured to permit adequate review and analysis of its effectiveness, and to maintain documentation that provides guidance for implementing the program.

The format and content requirements for training program development, verification, and validation are provided in DOE Order 5480.20A. The requirements are implemented for RHWM facilities through the following *ES&H Manual* Documents:

- 40.1, “LLNL Training Program Manual.”
- 40.2, “Environment, Safety & Health Training and Education.”
- 50.1, “Personnel Selection, Qualification, Training, and Staffing at LLNL Nuclear Facilities.”

Training may include OJT, classroom training, and/or computer-based training. The minimum training requirements for RHWM employees working in operational zones are identified in the FSPs.

12.4.1 Development of Training

The RHWM Division’s *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* (LLNL latest revision-b), *ES&H Manual* Document 40.2, “Environment, Safety & Health Training and Education,” and *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” require that training content be such that employees can perform their responsibilities and apply their skills and knowledge to provide maximum protection for themselves, fellow employees, LLNL facilities, the public, and the environment. Detailed information on the technical content development of training program requirements is contained in Appendix A of *ES&H Manual* Document 40.1, “LLNL Training Program Manual.” The training program representative meets with RHWM management and subject-matter experts for input to course lesson plans. The draft course material is reviewed by management and subject-matter experts for accuracy before being finalized.

The RHWM's *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division* spells out the various training courses required for each RHWM job assignment. The training matrix is maintained online to allow for easy access to the most up-to-date copy.

12.4.2 Maintenance of Training

To keep RHWM training materials current, the RHWM training program representative reviews all RHWM procedures and changes to procedures and has access to the RHWM server that contains the latest procedures. The training representative meets periodically with the RHWM area supervisors to stay current on their operations and to determine any new training needs, or changes to existing courses, within their areas of responsibility. The training representative holds a monthly training meeting with RHWM management personnel. This enables the training program representative to stay current on changes occurring within RHWM facilities so training materials can be updated or new training materials developed, as needed.

Training records for RHWM facility workers are maintained on a computer database. The LLNL database is used by LLNL personnel, managers and training organizations throughout the Laboratory as a tool to monitor training and as the repository for course-completion information. The database is regularly updated as training is completed. Original records are maintained by the training organization.

12.4.3 Modification of Training Materials

Procedures for identifying and correcting training program deficiencies are contained in Section 7.2 of *ES&H Manual* Document 40.1, "LLNL Training Program Manual." Students are also asked to submit comments on their training via course evaluation forms. Supervisors and subject matter experts are asked to alert the training program representatives whenever operations or regulatory requirements change. Course material is periodically reviewed to determine if changes are necessary. Course lesson plans and materials are then updated accordingly.

12.5 References

DOE (1994), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities,* DOE Order 5480.20A, Department of Energy, Washington, DC, November 15, 1994.

DOE (2001), *Conduct of Operations Requirements for DOE Facilities,* DOE Order 5480.19, Change Notice 1, U.S. Department of Energy, Washington, DC, October 23, 2001.

LLNL (latest revision), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867.

LLNL (latest revision-a), *Radioactive and Hazardous Waste Management Division Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, M-078-92, latest revision.

LLNL (latest revision-b), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-116655, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 13
HUMAN FACTORS

13.1 Introduction

This chapter discusses the human factors engineering that helped shape the design of the Waste Storage Facilities. Per DOE-STD-3009-94, Change Notice 3 (DOE 2006), the discussion of human factors is limited to human factors engineering. Human factors engineering focuses on designing facilities, systems, equipment, and tools so they are sensitive to the capabilities, limitations, and needs of humans. Human factors engineering supports, and is supported by, the hazard and accident analyses described in Chapter 3.

13.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 5480.19, Change Notice 2	Conduct of Operations Requirements for DOE Facilities
DOE O 5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management

13.3 Human Factors Process

The human factors process considers the involvement of humans in potential operational accidents at the facilities and identifies the important human–machine interfaces for safety SSCs. Involvement may be with respect to prevention (e.g., inspection, analytic, and surveillance activities, or container handling or moving) and mitigation (e.g., shutdown of operations during off-normal or emergency situations) activities.

13.4 Identification of Human–Machine Interfaces

Safety-significant SSCs were identified as a function of the hazard analysis as discussed in Chapters 3 and 4. The Process Hazard Analysis (PrHA) describes the accidents that are likely to involve workers. By focusing on worker aspects of the hazard analysis, the most important human–machine interfaces with the safety SSCs can be identified. The following human factors related controls are defense-in-depth:

Training

- The human–machine interface is operators driving vehicles to transport waste.

Maintenance, testing, and inspection (MT&I)

- The human–machine interface is the maintenance and operation of test equipment to assure the integrity of the TRU waste container safety-significant SSCs.
- The human–machine interface is the maintenance and inspection of equipment used to transport waste.

TRU waste containers stacked no more than 2 high

- The human–machine interface is operation of the forklift used in stacking.

13.5 Optimization of Human–Machine Interfaces

Human factors elements in the facilities include allowances for spacing of TRU waste containers. Adequate lighting is supplied to ensure that operators can see when they are operating equipment and vehicles. Certain facilities are also equipped with emergency lighting to guide a worker to safety.

All work in the RHWM facilities is performed by personnel trained for that task or supervised by trained personnel. As part of their training, personnel are made cognizant of major pieces of equipment. A more detailed discussion of worker training is presented in Chapter 12.

Operating personnel wear protective equipment as required. When required, respirators and other specific personnel protection devices are used. The facilities are designed with eyewashes and showers available to workers in accordance with applicable codes.

RHWM Division personnel use procedures in their daily work. Where applicable, these procedures list the appropriate personal protective equipment required for each operation. In addition, LLNL's Hazard Control Department assigns safety professionals to support RHWM operations. Personnel include industrial hygienists, industrial safety specialists or experts, and health physicists. These professionals prepare hazard assessment and control forms for operations to assure respirators and other personal protective equipment are specified and appropriate for the work to be performed. The hazard assessment and control forms specify the safety equipment that must be in place and/or worn by RHWM personnel when performing an operation. The RHWM Division maintains these forms on file.

Forklifts used in RHWM facilities are designed with consideration given to human safety, comfort, and operational ease. Forklift operators are trained in the use of such equipment and are generally experienced in transporting waste containers at LLNL. Operators are licensed within the LLNL training system to operate forklifts; this training includes formal instruction, hands-on training, and a performance evaluation.

At a minimum, two persons are required for movement of waste if self-rescue cannot be performed. Only one person is required for inspections and maintenance. However, no person shall perform an operation that might render them incapable of self-rescue without being in contact with another person.

13.6 References

DOE (1994), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, DOE Order 5480.20A, Department of Energy, Washington, DC, November 15, 1994.

DOE (2001), *Conduct of Operations Requirements for DOE Facilities*, DOE Order 5480.19, Change Notice 2, U.S. Department of Energy, Washington, DC, October 23, 2001.

DOE (2006), *Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports*, DOE-STD-3009-94, Change Notice 3, U.S. Department of Energy, Washington, DC, March 2006.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 14
QUALITY ASSURANCE

14.1 Introduction

This chapter outlines the Quality Assurance (QA) Program and Organization, which integrates quality management with the appropriate requirements of environmental regulations and guidance documents. This chapter provides information regarding the management and assurance of quality in those activities that are applicable to the Radioactive and Hazardous Waste Management (RHWM) Division, specifically to the Waste Storage Facilities.

14.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

Code of Federal Regulations

10 CFR 830, Subpart A	Quality Assurance Requirements

14.3 Quality Assurance Program and Organization

LLNL endorses the application of quality management and recognizes the role of a coordinated quality assurance management program. The Waste Storage Facilities are nonreactor nuclear facilities that come under the jurisdiction of the *LLNL Quality Assurance Plan* (LLNL latest revision-a) and 10 CFR 830, Subpart A. RHWM addresses all requirements of 10 CFR 830, Subpart A, and the LLNL QA plan in the *Radioactive and Hazardous Waste Management Division Quality Assurance Plan* (RHWM QAP) (LLNL latest revision-b).

The purpose of the RHWM QAP is to ensure that RHWM management provides planning, organization, direction, control, and support to achieve the organization's objectives; that the line organizations achieve quality; and that overall performance is reviewed and evaluated using a thorough assessment process.

The RHWM QAP serves as the primary QA reference for personnel assigned to, or assisting in, performing work activities within the Waste Storage Facilities. This QAP also serves as the basis for audits and reviews, identifies formal controls and documentation requirements, and provides a means of feedback to verify the effectiveness of controls and achievement of quality goals. The QAP is implemented through procedures, instructions, and procurement documents established by the RHWM Division. Operations and maintenance in the Waste Storage Facilities are subject to the LLNL RHWM QAP.

The RHWM QAP defines QA requirements for activities in the Waste Storage Facilities, including interfaces with the *LLNL Radioactive Waste Program Certification and Quality Assurance Plan* (LLNL latest revision-d). The Packaging and Transport Department Quality Assurance Plan interface requirements are also defined in the RHWM QAP.

The structure of RHWM and the relation of the line organization to the QA group are outlined in the RHWM QAP. The RHWM QA Manager is responsible for direction of the RHWM QA program and for developing, maintaining, and verifying the RHWM QA program. RHWM line management is responsible for ensuring that appropriate procedures and controls are developed and implemented for assigned tasks, that applicable standards have been identified, and that compliance with the standards is verified. All vendors, contractors, subcontractors, or other LLNL organizations must comply with applicable LLNL/RHWM QA program element requirements. Additional organizational summary material is provided in Chapter 17, *Management, Organization, and Institutional Safety Provisions.*

14.4 Quality Improvement

The RHWM QAP describes control of nonconformances through the nonconformance and corrective action process. The process includes initiation of a nonconformance and corrective action report (NCAR). Implementing procedures, developed at the division level, further define the process for reporting on tracking, issuing, dispositioning, evaluating, and closing nonconformance reports. The LLNL Lessons Learned program also provides information to improve the quality and safety of operations and facilities.

14.5 Documents and Records

Documents that specify QA requirements or prescribe quality-affecting activities are prepared, reviewed, and released for issuance and distribution in accordance with written procedures. Document control and records management requirements are identified in the RHWM QAP.

14.6 Quality Assurance Performance

14.6.1 Work Processes

Work processes are performed to established technical standards and administrative controls. Work is performed under controlled conditions using approved instructions, procedures, or other appropriate means. Adherence to established work processes is ensured through management oversight and periodic assessments.

14.6.2 Design

Design activities for the RHWM Waste Storage Facilities, including modifications, are controlled in accordance with the RHWM QAP, which includes requirements for controlling design inputs, outputs, verification, technical review, alternate calculations and analyses, peer reviews, design-change control, interface control, and QA records.

14.6.3 Procurement

The requestor and RHWM Cost Account Manager are responsible for ensuring that procurement documents include appropriate technical, regulatory, LLNL Supply Chain Management Department, and

QA requirements. The RHWM QA Manager reviews quality-affecting procurement documents. These requirements are met through both internal RHWM procurement procedures and LLNL procurement department procedures. RHWM procedures ensure that procurement documents and their changes are reviewed and approved. Procurement activities are planned and documented.

Selection of vendors is based on an evaluation of the capability to provide items, services, and other products in accordance with requirements of the procurement documents. Qualified vendor performance is verified periodically through inspection, surveillance, audit, or test.

Containers that are used for packaging hazardous material or hazardous waste, including TRU waste containers, are procured through the Packaging and Transport Department in accordance with the Packaging and Transport Department Quality Assurance Plan.

14.6.4 Inspecting and Testing for Acceptance

When it is necessary to ensure that required inspections and tests are performed, the status of inspection and test is identified either on the items or in documents traceable to the items. This approach ensures that items that have not passed the required inspections and tests are not inadvertently installed, used, or operated. Inspections are performed subject to the RHWM QAP.

14.6.5 Independent Assessment

Audits, completed by LLNL staff , are the primary method for independent assessment and focus on improving items and processes. The emphasis is on achieving quality by department-line organizations. Audits and surveillance are performed in accordance with written procedures or checklists. Activities are evaluated against specific criteria and objectives. Quality verification reports, where appropriate, detail corrective actions, identification of root causes, actions to prevent recurrence, lessons learned, and actions to be taken for improvement.

14.7 References

CFR (10CFR830), Subpart A, "*Quality Assurance Requirements*," Nuclear Safety Management, U.S. Department of Energy, Code of Federal Regulations, Title 10, Office of the Federal Register, Washington, DC.

LLNL (latest revision-a), *LLNL Quality Assurance Program*, Lawrence Livermore National Laboratory, Livermore, CA, latest revision.

LLNL (latest revision-b), *Radioactive and Hazardous Waste Management Division Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, M-079-92, latest revision.

LLNL (latest revision-d), *LLNL Radioactive Waste Program Certification and Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-148488, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 15
EMERGENCY PREPAREDNESS PROGRAM

15.1 Introduction

This chapter provides an overview of the emergency preparedness program for Radioactive and Hazardous Waste Management (RHWM) Division personnel at the Waste Storage Facilities.

15.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for the facility, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 151.1, Change Notice 2	Comprehensive Emergency Management System
DOE O 231.1A	Environment, Safety, and Health Reporting

15.3 Scope of Emergency Preparedness

ES&H Manual Document 22.1, “Emergency Management,” describes the emergency management system and provides emergency planning procedures for operational emergencies, which are defined as significant accidents, incidents, events, or natural phenomena that could seriously impact the safety or security of LLNL's employees and facilities or the environment. The *LLNL Emergency Plan* (LLNL latest revision-a) provides additional information.

As a research facility, LLNL employs many energy sources, ranging from chemicals and explosives to radiation and microwaves, high-powered lasers, and high-voltage electricity that have the potential to pose serious hazards. The scope and extent of emergency planning and preparedness at LLNL address these hazards as well as hazards that have the potential for larger, more serious injuries, such as fires, earthquakes, or security-related incidents. LLNL uses an emergency management system (known as the Incident Command System) to respond to and mitigate the consequences of operational emergencies. The LLNL’s emergency management system responds to and mitigates potential consequences of onsite and significant nearby emergencies that could threaten LLNL workers, the public, or the environment.

The degree of emergency planning and preparedness for a particular facility corresponds to the type and scope of hazards and the potential for harm. The Waste Storage Facilities handle, stage, treat, and store radioactive, mixed, and hazardous wastes. Emergency response for hazardous and radioactive materials is covered in *ES&H Manual* Document 22.1, “Emergency Preparedness and Response,” and Document 22.6, “Exposure to Radiation in an Emergency.”

Facility hazards identified in the hazard analysis include vehicle accidents (spills and fires), electrical accidents (fire), deflagration, aircraft crash, high winds (spills), lightning (fire), flood (spill), and earthquakes (spills and fires). In general, emergencies at the Laboratory can be divided into three categories:

- Local emergencies that only involve a few people or a single location.
- Local emergencies with a potential to spread and become a large-scale incident.
- Large-scale or wide-spread emergencies that can affect multiple locations or facilities.

Emergency preparedness planning for large accidents (including an aircraft crash) is described in Section 15.4 and can involve offsite support organizations and hospitals. Smaller, local accidents could often be responded to by the LLNL onsite Fire Department and support organizations.

Because the Waste Storage Facilities may experience some flooding in the 2,000-year design basis flood, possibly leading to water 9 inches above the floor in the DWTF in the worst case, the following emergency provisions are established:

- Move waste to another part of the facility or another facility if enough notice of a flood is provided and if there is capacity.
- Sandbag the entrances to the facilities in the DWTF Storage Area if there is enough notice.

In any emergency, the Laboratory's onsite Fire Department and Protective Force Division can be supported by specialists in Hazard Control, the Environmental Protection Department, RHWM, and Health Services, if necessary. Fire protection at the Waste Storage Facilities is described in Chapter 11.4.

The *Self-Help Plan* (LLNL latest revision-b), RHWM Contingency Plan, and Facility Safety Plans (FSPs) are designed to be used with the *LLNL Emergency Plan*. Self-help organizations are needed because a large-scale emergency, such as an earthquake, may overburden the onsite Emergency Response Organization (ERO), and there may be significant delays to some requests for assistance because responses may have to be prioritized. Under such conditions, departments, divisions, or facilities will need to react locally to an emergency by using the self-help organizations for periods of eight hours or longer. The Self-Help Plan defines roles and responsibilities for facility personnel during emergency conditions. Responsibilities center on accounting for personnel, responding to injuries, and search-and-rescue operations, as follows:

- Ensuring that all personnel who should be in an assigned area are accounted for.
- Providing care and protection to personnel.
- Providing first aid.
- Transporting injured personnel.
- Assessing and reporting emergency situations.
- Protecting facilities.

Following events that could significantly affect the building structure, an assessment will be performed prior to allowing re-entry of personnel into the building.

15.4 Emergency Preparedness Planning

The *LLNL Emergency Plan* describes the system's organizational elements, interfaces, authorities, responsibilities, resources, and actions to be taken in response to emergencies.

15.4.1 Emergency Response Organization

The RHWM Division handles small incidents with the RHWM Storage and Disposal Group Leader or alternate as the emergency contact.For a release to be determined a small incident, all of the following criteria must be met:

- The nature and potential hazards are known.
- The release presents no actual or potential threat to human health or the environment.
- The incident results in no injury, or only minor injury requiring first aid, and no loss of work time.

For large incidents, personnel are to evacuate the immediate area to maintain their own safety, and the onsite Fire Department is contacted. The first or senior Fire Department officer dispatched to or present at the incident site becomes the incident commander (IC) until relieved by the Duty Chief; the Duty Chief then becomes the IC. The IC is responsible for assessing the emergency conditions, making the initial emergency level classification, initiating onsite response activities, and requesting support from offsite organizations.

The Fire Department Duty Chief is responsible for notifying the Laboratory Emergency Duty Officer (LEDO) and initiating notification of the DOE and other offsite agencies. The LEDO may direct activation of the Emergency Operations Center (EOC) and notification of the Emergency Management Team at which time the LEDO assumes the role of Emergency Director. The Emergency Director also directs the efforts of the Emergency Response Organization to identify the material released and to assess potential or actual health consequences.

The primary means of activating the Emergency Response Organization is through the Communicator, a digital call/paging system. For Operational Emergencies, the IC classifies the incident and makes the initial notification. Follow-up notification comes from the Emergency Operations Center under the direction of the Emergency Director.

Agreements with offsite emergency response organizations are discussed in the *LLNL Emergency Plan*. Response to fire, medical, and hazardous materials incidents on LLNL property is provided by the Alameda County Fire Department under contract to LLNL. The Alameda County Fire Department staffs both LLNL fire stations with cleared, trained fire fighters and fire fighter/paramedics. Both LLNL and the Alameda County Fire Department have ongoing contacts with local response agencies, mutual-aid agreements, and the response lead per California requirements. The State of California provides additional emergency assistance as described in the California Disaster and Civil Defense Master Mutual Aid Agreement. State agencies provide assistance at the direction of the Governor's Office of Emergency

Services (OES). The Alameda County Sheriff's OES is the lead offsite response coordination agency for major emergency and disaster situations at or affecting the Livermore site. In addition, the Alameda County Fire Department is signatory to the State of California Master Mutual Aid Agreement for fire services and the Alameda County Mutual Aid Response Plan. Upon request, associated fire services will respond with personnel and equipment to support LLNL emergencies. The Livermore/Pleasanton Fire Department coordinates its activities with the Alameda County OES. If the primary communication links become unavailable, the Livermore/Pleasanton Fire Department assists in activating the Amateur Radio Emergency Services (ARES). LLNL has a Memorandum of Understanding (MOU) in place with Valley Care Medical Center and Eden Medical Center to provide medical support for LLNL contaminated patients.

15.4.2 Assessment Actions

The RHWM Storage and Disposal Group Leader or alternate decides the level of an emergency (small or large incident) and may consult with the Hazard Control Department ES&H Team for help with this assessment. In case of a radioactive release, the Hazard Control Department ES&H Team is called to monitor radioactivity levels. If personnel have any doubt about their ability to clean up a release properly and safely, or if the incident is determined to be a large incident, the LLNL onsite Fire Department is notified immediately.

The *LLNL Emergency Plan* defines and describes Operational Emergency classifications (i.e., "Not Requiring Further Classification," "Alert," "Site Area Emergency," and "General Emergency"). Upon arrival at the scene, the IC determines if the incident is an Operational Emergency. The classification is made using the applicable Emergency Action Levels, which provide guidance to classify under conditions of limited real-time availability of event-specific data, such as distance to the site boundary, and applicable Protective Action Guides or Emergency Response Planning Guidelines.

An Alert would be declared for:

- An actual or potential substantial degradation in the level of control over hazardous materials (radiological and nonradiological) such that the radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material is expected to exceed the applicable Protective Action Guide (PAG) value beyond 30 meters, but not greater than the facility boundary.
- An actual or potential substantial degradation in the level of safety of a facility or process that could, with further degradation, produce a Site Area Emergency or General Emergency.

A Site Area Emergency would be declared for:

- An actual or potential major failure of functions necessary for the protection of workers or the public. The radiation dose from any release of radioactive material or concentration in air from any release of other hazardous material is expected to exceed the applicable Protective Action Guide (PAG) or Emergency Response Planning Guideline (ERPG) values beyond the facility boundary or exclusion zone boundary. The PAG or ERPG value is not expected to be exceeded at or beyond the site boundary.
- Actual or potential major degradation in the level of safety of a facility or process that could, with further degradation, produce a General Emergency.

A General Emergency would be declared for:

- Actual or imminent catastrophic reduction of facility safety systems with potential for the release of large quantities of hazardous materials (radiological or nonradiological) to the environment.
- The radiation dose from any release of radioactive material or a concentration in air from any release of other hazardous material is expected to exceed the applicable PAG or ERPG value at or beyond the site boundary.

In the event of an accidental release to the environment, release response would be implemented and, if the incident were declared a large incident, the National Atmospheric Release Advisory Capability (NARAC) Center may be requested to advise the Emergency Management Team on implications of toxic or radiological releases. The NARAC center can estimate the effects and atmospheric dispersion of hazardous and radioactive waste releases within the immediate area surrounding a release or within Northern California. The NARAC center is equipped to perform detailed atmospheric dispersion calculations, allowing an accurate tracing of hazardous and radioactive waste dispersion. The capability of this system allows the various response teams to have information on any hazardous and mixed waste (radioactive material) concentrations resulting from an accidental release. Additional near-event dispersion calculations are available from the LLNL Hazard Control Industrial Hygiene Group.

15.4.3 Notification

Communications systems are in place for the prompt, initial notification of Laboratory emergency response personnel, onsite personnel, and emergency response personnel/organizations offsite, including NNSA, DOE Headquarters, and other federal, state, and local organizations. Communication systems are also in place to provide for continuing, effective communication among the emergency response organizations, both offsite and onsite, throughout an Operational Emergency.

Notification of emergency response personnel is done through the Communicator, as described earlier in the chapter. DOE and offsite agency notifications shall be made within 15 minutes of the actual declaration of an Alert, Site Area Emergency, or General Emergency, and within 30 minutes of the actual declaration of an Operational Emergency not requiring further classification.

Follow-up notifications are provided on an hourly basis or whenever classification of the emergency event changes. The Alameda County Office of Emergency Services notifies other appropriate State of California entities and can use the State of California’s Emergency Broadcast System.

The External Relations and Communications is responsible for providing timely and accurate information to the community, news media, and Laboratory workforce on matters concerning health, safety, and operations during and following an Operational Emergency. During an emergency, the External Relations and Communications acts as the single point of contact for the news media, and as a principal source of information for Lab employees and community officials. It is also possible to coordinate the dissemination of information with outside agencies through the Joint Information Center.

LLNL employees are notified via the dedicated EVA system. Alternative emergency communication systems include Radio 1610, the Emergency Radio Paging System, the LLNL telephone system, emergency signals/alarms, and the emergency vehicle public address system.

15.4.4 Emergency Facilities and Equipment

This section briefly describes emergency equipment available to the Waste Storage Facilities. Such equipment includes emergency communication equipment, fire detection and suppression equipment, water supplies, emergency-response and spill-control equipment, and decontamination equipment.

Emergency Communication Equipment

Numerous methods for communicating emergency information are available, including:

- LLNL sitewide emergency paging system.
- Area emergency paging systems.
- Telephones.
- Radio pagers and radio transceivers.
- Horns, sirens, and klaxons.
- Portable loudspeakers and megaphones.

Fire Detection and Suppression Equipment

The FSPs specify locations of fire extinguishers throughout the facilities. Fire extinguishers are typically located in areas of specific fire hazards.

Section 11.4.4 provides information regarding the fire detection and suppression equipment at the Waste Storage Facilities. Discharge of water through fire sprinkler(s) sends a signal to the fire alarm control panel (FACP), and the FACP will forward the signal to the onsite Fire Department.

Fire alarm pull stations are provided at emergency egress points in some facilities. Speakers and strobe lights, where applicable, of the EVA system are strategically located to warn people to evacuate the buildings.

Water Supplies

Water supplies for all purposes, including emergency responses, are provided to the Waste Storage Facilities as part of the site-wide utility infrastructure.

Emergency-Response and Spill-Control Equipment

Several categories of emergency-response equipment are available to the Waste Storage Facilities, including spill-control equipment, response vehicles and heavy equipment, site safety equipment, personal protective equipment, and emergency assembly-point kits. The RHWM Contingency Plan provides details on location, control, testing, and maintenance of emergency equipment and supplies. The *LLNL Fire Protection Program* (LLNL latest revision-c) describes emergency equipment available for larger incidences that require mitigation by the LLNL onsite Fire Department.

15.4.5 Protective Actions

Protective action criteria are levels of hazardous material that indicate action is needed to prevent or limit exposure to the hazard. The IC will direct protective actions of affected onsite personnel based on the initial assessment. If initial projections indicate that a hazardous material plume may extend beyond the site boundary, or that protective action criteria may be exceeded offsite, the IC will make protective action recommendations to offsite agencies.

The onsite Fire Department has available Protective Action Guides for hazardous materials. Protective actions include standby for further information, shelter, and evacuate. Criteria for determining the best protective action for onsite personnel and the public are described in the *LLNL Emergency Plan*.

Onsite protective actions will be modified or lifted at the direction of the IC, with concurrence of the Emergency Director. Shutdown of operations is the responsibility of operations personnel in the affected building or facility. Emergency response information and follow-up health and hygiene surveys are documented.

LLNL's Health Services Department is a professional medical staff that is responsible for maintaining a detailed medical emergency response plan for providing medical care, using both LLNL and offsite facilities, during emergencies. In addition, the Emergency Management employs paramedics. The onsite medical facility includes a decontamination area that is designed for treatment of injured or noninjured radiologically or chemically contaminated personnel.

As described above under "Notifications," state and local response personnel and organizations are notified within 15 minutes of declaring an "Alert," "Site Area Emergency," or "General Emergency". Follow-up notifications are provided on an hourly basis or whenever classification of the emergency event changes. External Relations and Communications provides information to the public and news media during an Operational Emergency. The Alameda Office of Emergency Services notifies other appropriate State of California entities and can use the State of California's Emergency Broadcast System. The offsite agencies alert the public and provide guidance on what action to take.

15.4.6 Training and Exercises

Personnel at the Waste Storage Facilities participate in LLNL sitewide emergency drills and exercises. The *LLNL Emergency Plan* describes how emergency preparedness is maintained through use of training and exercises. LLNL conducts a coordinated program of drills and exercises to provide emergency-response training and to establish a method for evaluating response capability and readiness.

Drills are designed to develop and maintain personnel emergency-response skills. They are conducted separately by each ERO and reflect the organization's specific training needs, which have been discovered during prior drills. An integrated exercise is conducted annually to test communication and notification among organizations.

The Emergency Preparedness Section's Exercise Program includes an annual, full-participation exercise based on rotating scenarios, such as a natural disaster, security incident, or hazardous material incidents. The scenarios are designed to test the operational capability of individual organizations.

A Self Help drill is conducted annually. The Self Help program serves as a vehicle for training employees to help themselves during a catastrophic event, such as an earthquake, where professional first responders may be overwhelmed by calls for assistance. Personnel are trained to evacuate in accidents (e.g., large spill or fire) through an established training program described in Section 12.4, Training Program.

15.4.7 Recovery and Reentry

Recovery includes incident assessments and investigation, recovery planning, scheduling, repair, restoration, and return or relocation. The *LLNL Emergency Plan* describes the provisions made for recovery from an Operational Emergency and reentry into the affected facility. The Emergency Director is responsible for terminating an operational emergency when applicable criteria are met. Such termination constitutes entry into the recovery phase.

Prior to emergency termination, a recovery organization will be established. The Emergency Director will appoint a Recovery Manager who designates a Recovery Team. The Team may include advisors from the Environmental Protection Department, Hazard Control Department, and Plant Engineering. The Recovery Manager will continue communications and coordination with offsite federal, state, and local officials, as needed.

The Recovery Plan indicates that emergency response personnel will be deployed to evaluate an emergency situation and determine when it is safe to return the facility to normal operations. Following such determination, the Recovery Manager notifies the Hazard Control Department ES&H Team leader and transfers responsibility for the facility to the facility manager.

15.5 References

LLNL (latest revision-a), *LLNL Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-113311, latest revision.

LLNL (latest revision-b), *Self-Help Plan Radioactive and Hazardous Waste Management Division*, Environmental Protection Department, Lawrence Livermore National Laboratory, Livermore, CA, latest revision.

LLNL (latest revision-c), *LLNL Fire Protection Program*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-116646, latest revision.

NNSA/LLNS (2007), *Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security*, No. DE-AC52-07NA27344, effective October 1, 2007.

CHAPTER 16
PROVISIONS FOR DECONTAMINATION AND DECOMMISSIONING

16.1 Introduction

This chapter provides a discussion of future decontamination and decommissioning (D&D) activities, and it also provides a conceptual D&D plan. Because of the similarity of Resource Conservation and Recovery Act (RCRA) requirements to those found in the DOE orders and guides pertaining to D&D operations, this chapter summarizes information contained in the RCRA Closure Plan for these facilities (LLNL latest revision). The Waste Storage Facilities will be closed according to requirements of RCRA; the California Hazardous Waste Control Law (HWCL); the Federal Facility Compliance Act (FFCA); and the LLNL Federal Facility Agreement (FFA) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Section 120, as agreed upon by the U.S. Environmental Protection Agency (EPA), the U.S. Department of Energy (DOE), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB).

The good-practice guides (surveillance and maintenance, deactivation, and decommissioning) associated with DOE O 430.1B will be used as guidance for the disposition of this facility, following principles in the appropriate chapters of LLNL's *ES&H Manual*. The integrated safety management concepts in DOE P 450.4 and DOE G 450.4-1 are reflected in the RCRA-required health and safety plan, which is an integral part of the RCRA Closure Plan. This plan also incorporates the ideas found in DOE-STD-1120-98, including work planning and identification, integrated hazard analysis, hazard controls and ES&H documentation, and work performance.

16.2 Requirements

This section identifies DOE and industrial design orders, codes, standards, and regulations that establish the safety basis for these facilities, that were used in preparing this chapter, and that pertain to the safety analysis. The list includes applicable requirements derived from the NNSA/LLNS Contract (NNSA/LLNS 2007) and portions of other requirements.

U.S. Department of Energy

DOE O 5400.5, Change Notice 2	Radiation Protection of the Public and the Environment
DOE O 430.1B	Real Property Asset Management

Code of Federal Regulations

10 CFR 830	Nuclear Safety Management
10 CFR 835	Occupational Radiation Protection

40 CFR 264, Subpart G	Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities -- Closure and Post-Closure

California Code of Regulations

22 CCR 66264, Article 7	Standards for Owners and Operators of Hazardous Waste Transfer, Treatment, Storage, and Disposal Facilities - Closure and Post-Closure

16.3 Description of Conceptual Plan

Prior to the start of D&D activities, an Implementation Plan that describes the actual work to be performed in the facility and methods for complying with DOE orders and the *ES&H Manual* will be developed. This plan will be based on an evaluation of all contamination sources identified within the facility. It will also include data from contamination files and detailed budgets and schedules. It is anticipated that the Implementation Plan will resemble the RCRA Closure Plan.

The waste inventory of the Waste Storage Facilities will be decreased significantly before D&D activities begin. This means that the radioactive inventory will also decrease to well below Nuclear Hazard Category 3 limits stated in DOE-STD-1027-92, Change Notice 1.

Before decontamination, a pre-sampling survey may be conducted to determine where contamination exists within each unit or structure. Following the survey, sampling could be conducted, analytical results compared to the respective regulatory limits, and the appropriate decontamination activities undertaken. RHWM may elect to perform decontamination before sampling is undertaken. Sampling will be performed as required, and analytical results will be evaluated against established limits. If it is determined that further decontamination will not remove the identified contamination, decontamination activities will cease, and the item will be disposed of according to the level and type of contamination.

Sampling and analysis will be done with waste minimization as a goal, and with special emphasis on mixed waste minimization. Therefore, the first attempt to decontaminate equipment or a structure may be by washing the surface using pre-developed techniques. The floors of the Waste Storage Facilities are typically epoxy-coated to simplify decontamination activities.

Materials generated during D&D activities will be evaluated against appropriate environmental requirements to ensure appropriate handling and disposal.

The Closure Plan includes, but is not limited to, discussions of the following topics that will enable final closure certification at the end of the facility's operating life:

- **General Facility Description:** a general discussion of LLNL, its location, operations, and associated hazardous waste management activities.
- **Waste Management Unit Information:** an overview description of the specific waste-management units, including dimensions, location, construction materials, historical uses, potential historical contaminants, and containers and equipment used to manage waste at the unit.

- **Closure Performance Standard:** a discussion of several topics, including the sampling and analysis methodology, removal and disposal of contaminated equipment and structural components, and evaluation of wastes to regulatory definitions.
- **Maximum Waste Inventory:** a description of the maximum inventory of waste that could be in storage or treatment at any time during the operating life of the unit.
- **Schedule for Closure:** a discussion of the expected year of closure and a milestone chart showing the closure activities. The closure schedule provides a mechanism for tracking the progress of closure activities.
- **Inventory Removal Procedures:** a discussion of disposal options for waste generated during D&D activities.
- **Disposition of Equipment and Associated Structures:** a discussion of disposal of equipment; decontamination of equipment and structures, debris waste, and equipment used for treatment of waste (if appropriate); and demolition and/or removal of contaminated structures for onsite treatment or offsite treatment or disposal.
- **Closure Certification:** a discussion of certification and analyses to be performed to verify clean closure and to certify closure.
- **Site Safety and Health Plan:** a discussion of site hazards and controls for LLNL or contractor personnel to perform assigned tasks safely.

16.4 References

LLNL (latest revision). *Operation Plan for Hazardous Waste Treatment and Storage Facilities, Livermore Site*. Lawrence Livermore National Laboratory, Livermore, CA, latest revision.

NNSA/LLNS (2007), Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security, No. DE-AC52-07NA27344, effective October 1, 2007.

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CHAPTER 17
MANAGEMENT, ORGANIZATION, AND INSTITUTIONAL SAFETY PROVISIONS

17.1 Introduction

This chapter provides an overview of management, organization, and institutional safety provisions at the Waste Storage Facilities. LLNL has incorporated Integrated Safety Management (ISM) into all aspects of operations. The NNSA/LLNS Contract Appendix G (NNSA/LLNS 2007) has been used to select the most appropriate national consensus standards, along with appropriate LLNL-developed standards. Organizations and personnel with responsibilities for safety, and interfaces among the organizations, are described in this chapter. In addition, descriptions are provided of safety consciousness, safety culture, performance assessment, configuration and document control, occurrence reporting, and staffing and qualification for the Waste Storage Facilities.

17.2 Requirements

The safety program for the RHWM Division facilities is administered through a series of hierarchical documents that state responsibilities and give direction for safe operations. The *ES&H Manual* (LLNL latest revision-a) is a compilation of ES&H-related requirements and policy. Requirements in the *ES&H Manual* are based on NNSA/LLNS Contract Appendix G standards (NNSA/LLNS 2007)identified for the specific work and associated hazards, and LLNL best practices that management has determined are requirements. The Appendix G standards set was derived from statutes, regulations, DOE Orders, and national and internally developed consensus standards. The Appendix G standards set is found in the Contract NO. DE-AC5207NA27233 agreement between Lawrence Livermore National Security, LLC (LLNS, LLC) and NNSA (NNSA/LLNS 2007). The *ES&H Manual* also describes implementation of the ES&H management commitments made in the Laboratory's *Integrated Safety Management System Description* (LLNL latest revision-b). Adherence to the requirements and processes described in the *ES&H Manual* ensures that safety documents across the Laboratory are developed in a consistent manner.

The next level of administrative safety documentation is the RHWM facility safety plans (FSPs) and integration work sheets with safety plans (IWS/SPs), followed by procedures. The FSPs include not only safety requirements specific to the facility as derived from the *ES&H Manual* but also from the Technical Safety Requirements developed in response to the *ES&H Manual* Document 51.2, “Technical Safety Requirements.” To ensure that document contents are appropriate for current operations, FSPs, IWS/SPs, and procedures are reviewed on an established schedule in accordance with the *ES&H Manual*. *ES&H Manual* Document 2.2, “Managing ES&H for LLNL Work,” discusses these documents in more detail.

When any new activity or a change to an existing activity is planned, an Integration Work Sheet (IWS) is developed following *ES&H Manual*, Document 2.2, “Managing ES&H for LLNL Work.” The IWS process ensures that a careful review is performed both by ES&H subject-matter experts and RHWM management. New or modified activities may also be subject to review under the Configuration Management Program and/or Unreviewed Safety Question (USQ) process. All applicable parts of the

Occupational, Safety and Health rules found in 29 CFR 1910 are identified as standards that RHWM uses to provide workers at the Waste Storage Facilities with a safe and healthful working environment.

17.3 Organizational Structure, Responsibilities, and Interfaces

The overall RHWM organizational structure is presented in this section. Included are safety provisions in the RHWM organizational structure that help ensure and enhance facility safety.

17.3.1 Organizational Structure

LLNL is a multi-program laboratory operated for the DOE by the Lawrence Livermore National Security, LLC. To accomplish its mission, LLNL operates through a matrix system, with each major organization headed by a programmatic associate director or program leader. The management structure is summarized in **Figure 17-1**. The nuclear facility managers are matrixed from Nuclear Operations into the Weapons and Complex Integration (WCI) principal directorate.

17.3.2 Organizational Responsibilities

Operational and management personnel responsibilities are outlined in this section. Included in the discussion are interfaces with other organizations, line operating organizations and safety organizations.

Operational and Management Personnel

ES&H Manual Document 2.1, “Laboratory and ES&H Policies, General Worker Responsibilities, and Integrated Safety Management,” provides specific roles for personnel based on their position. RHWM personnel manage the Waste Storage Facilities. They are responsible for storing and preparing shipments of LLNL’s radioactive, hazardous, and mixed waste for off-site treatment and/or disposal. Lines of authority, responsibility, and communications are established and defined for the highest, down to intermediate management levels, including all safety and operating organization positions.

WCI has line responsibility. They execute the scope, manage the budget and schedule, and provide day to day direction of the facility managers assigned to Nuclear Operations. The nuclear facility managers are matrixed from Nuclear Operations into the WCI principal directorate. In this role, they are accountable to the Nuclear Material Technology Deputy Principal Associate Director for the safe and compliant operation of the facility.

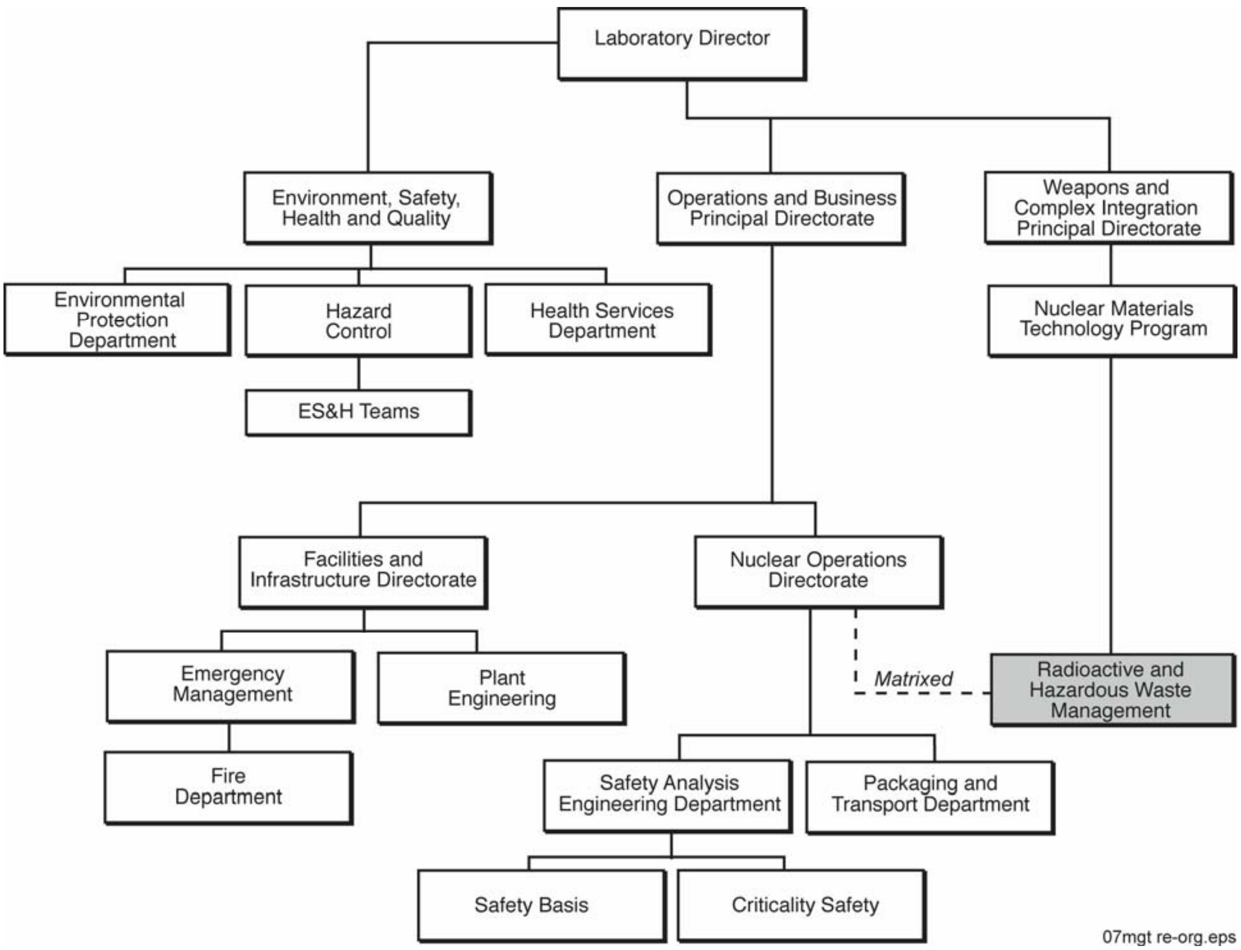
The RHWM Division Leader/Deputy Division Leader is responsible for overall facility operation and shall delegate, in writing, the succession to this responsibility during any absence. Delegation shall be to a qualified individual. The RHWM Division Leader is responsible for safe operation within the Waste Storage Facilities. Safe operation includes interface requirements with other site organizations and facilities to ensure the availability of Hazard Control Department subject matter experts, fire protection, electric power, utilities, and related needs.

The RHWM Storage and Disposal Group Leader is the Facility Manager of the Waste Storage Facilities and is responsible for the operational functions. The group leader is responsible for overall site safety and has control over those activities necessary for safe operation and maintenance of the Waste Storage Facilities.

The Facility Point of Contact (FPOC) for the Waste Storage Facilities is the Storage and Disposal Nuclear Facilities Operations Supervisor. Some of the FPOC responsibilities include concurring that work can be performed within the safety envelope of the facility, identifying hazards associated with the work location and communicating them to the responsible work management chain, participating in pre-start review of work (when one is conducted), evaluating proposed operational or activity changes against the facility's existing ES&H documentation (e.g., the authorization basis), and concurring that work may proceed in the building, prior to the onset of work.

Individuals who carry out health physics and QA functions, have independent safety review, audit, and compliance oversight. A health and safety technician, whose qualifications meet DOE Order 5480.20A (DOE 1994) requirements, shall be on call when radioactive material is present in the Waste Storage Facilities.

Figure 17-1. Management Organization Chart



Interfaces with Other Organizations

Members of the Hazard Control ES&H Team 1 may be called in to advise on planned and ongoing operations, conduct hazard assessments, and support RHWM at the Waste Storage Facilities during emergency incidents. The ES&H Team is responsible for promptly notifying RHWM management in the event of any unexpected monitoring results (e.g., dosimetry). This team consists of specialists in industrial hygiene, industrial safety, health physics, environmental protection, explosives safety, fire protection engineering, and criticality safety.

An environmental analyst of the Environmental Operations Group of the EPD serves on the Hazard Control ES&H Team.

The LLNL Emergency Management (Fire Department) is called in to handle major incidents. Details of emergency management at LLNL are found in the *LLNL Emergency Plan* (LLNL latest revision-c).

Technical and Engineering Support, Maintenance, and Modifications

Most large-scale design, construction, and maintenance efforts at LLNL are coordinated through Plant Engineering. Within the RHWM Division, the Waste Treatment Group Leader provides facility coordinators, fabrication technicians, and maintenance technicians to support smaller projects.

Safety Issue Discovery, Communication, Management, and Resolution

Safety issue discovery takes place in a variety of ways, ranging from a worker's concern to a formal audit. Safety concerns from workers are transmitted to their supervisor who can act on them directly, often with input from the ES&H Team, or they can be passed on to the group leader for action. Employees are aware that a variety of additional options are in place to raise safety issues. Audit results are typically forwarded to the division leader and corrective action plans developed by the appropriate group leader. For some issues, a nonconformance report can be issued in accordance with the *RHWM Quality Assurance Plan* (LLNL latest revision-d).

For safety issues that meet requirements found in the LLNL implementation of the Occurrence Reporting process, the institutional procedure is found in the *ES&H Manual* Document 4.5, "Incidents—Notification, Analysis, and Reporting." Corrective actions from occurrence reports are tracked to closure in the LLNL ES&H Issues Tracking System database as described in *ES&H Manual* Document 4.2, "ES&H Issues and Deficiencies Management." Corrective actions and closure of findings are described in the Safety and Environmental Protection Directorate *Integrated ES&H Management Program*.

LLNL has an active Lessons Learned program run by the Hazard Control Department. The RHWM Division submits issues of general usefulness to this program.

Independent Safety Review, Audit, and Compliance Determination

RHWM is subject to a variety of external (to LLNL) and internal audits. In addition to DOE audits, external audits include DNFSB, California Highway Patrol, Department of Transportation (DOT), and Department of Toxic Substance Control (DTSC) audits.

In terms of independent internal audits, LLNL staff carries out a variety of audits of RHWM activities, including those in areas such as criticality, nuclear facility authorization basis, and radiation worker protection. Findings from the audits are always tracked to closure in the LLNL ES&H Issues Tracking System database. .

Safety Analysis Services, Including USQ Evaluation

The Laboratory has a staff of trained safety analysts in the Safety Basis Division in Nuclear Operations Directorate. In addition, the RHWM Division maintains a staff of qualified personnel who perform USQ evaluations and develop DSAs and TSRs.

Support Services Such As Utilities and Other Offsite Support

The Plant Engineering Department provides telecommunications and utilities services. The Laboratory has backup sources for both electricity and water.

17.3.3 Staffing and Qualifications

This section summarizes the bases for staffing levels and the knowledge, skills, and abilities of personnel assigned to the Waste Storage Facilities. Included is a description of programs and provisions for monitoring safety performance of the staff.

The Training Implementation Matrix (TIM) for RHWM (LLNL latest revision-e) addresses the requirements of DOE Order 5480.20A, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*. *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” defines the LLNL training program. The FSPs list the minimum safety training requirements for employees who work in the Waste Storage Facilities operational zones.

The program associate director (AD) is responsible for carrying out the program’s technical work and for ensuring that LLNL health and safety policies are integrated into the program’s activities and plans. The program AD has the primary responsibility for ensuring:

- The safe conduct of all activities connected with program work.
- That program training responsibilities required by *ES&H Manual* Document 40.1, “LLNL Training Program Manual,” are carried out.
- The LLNL work force assigned is properly trained to carry out the work.
- That facilities and procedures used are appropriate for the work.

17.4 Safety Management Policies and Programs

Facility safety is maintained at the Waste Storage Facilities through safety management policies and programs as described in the following sections. The safety management program is established to ensure that any hazardous activities are defined, evaluated, planned, performed, assessed, and improved in accordance with LLNL’s Integrated Safety Management (ISM) policy and requirements.

17.4.1 Safety Review and Performance Assessment

As described in Section 17.2 above, when any new activity, or a change to an existing activity, is planned, an IWS is developed following the *ES&H Manual*, Document 2.2, “Managing ES&H for LLNL Work.” This work authorization control process requires hazardous work to be controlled by procedure, instruction, permit, or other such controlling documents and ensures that a careful review is performed both by ES&H subject-matter experts and RHWM management.

The Hazard Control Department's ES&H Team 1 provides independent safety oversight and support to RHWM facility operations. ES&H Team 1 is composed of representatives from various safety disciplines, including health physics, industrial hygiene, fire safety, environmental protection, and industrial safety. The representatives also provide independent reviews of FSPs, IWS/SPs, and selected procedures.

17.4.2 Configuration and Document Control

The RHWM Nuclear Facility Configuration Management Program (LLNL latest revision-f) is established in accordance with *ES&H Manual* Document 41.2, "Configuration Management" and ensures consistency between the appropriate design requirements, physical configuration, and documentation of SSCs necessary to protect workers and the public. The USQ process is performed in accordance with Document 51.3, "LLNL Unreviewed Safety Question (USQ) Procedure," in the *ES&H Manual*.

Maintenance activities and document control are discussed in Chapters 10 and 14, respectively. Any changes to documents or maintenance activities that may impact the safety basis are evaluated through the USQ process.

17.4.3 Occurrence Reporting

ES&H Manual Document 4.5, "Incidents—Notification, Analysis, and Reporting," describes notifications to be made at LLNL following an incident, reports that must be prepared, the methodology of incident analysis, and actions required to minimize the frequency of a similar incident recurring. This conforms to the requirements of DOE Order 231.1A (DOE 2003).

Staff members of the Waste Storage Facilities are responsible for initial reporting and for writing occurrence reports. In addition, occurrences with application to others are written up for the LLNL Lessons Learned program that is operated by the Hazard Control Department.

17.4.4 Safety Culture

To ensure that the Waste Storage Facilities are operated in a safe manner, LLNL has established various programs for self-assessment, monitoring, enhancing operational personnel performance, and corrective action. Periodically, several levels of LLNL management review LLNL safety procedures and operations to ensure their continued effectiveness. The safe operation of the Waste Storage Facilities is monitored by Hazard Control Department ES&H Team 1 to ensure that management is aware of risks and that necessary risks are minimized. Documents and procedures that help establish the safety culture at the Waste Storage Facilities are provided in the LLNL *ES&H Manual*. Other safety-related programs that are applicable include:

- Integrated Safety Management, including the IWS process.
- Directorate and RHWM self-assessments.
- Management pre-start, readiness assessment, and operational readiness reviews.
- Responsible individual and supervisor monitoring.
- Periodic review and revision of safety procedures.
- Conduct of operations.

- QA system monitoring.
- Nonconformance and corrective action reports.
- ALARA.
- Industrial safety and hygiene.
- Safety meetings.

17.5 References

DOE (1994), *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities*, DOE Order 5480.20A, Department of Energy, Washington, DC, November 1994.

DOE (2003), *Environment, Safety, and Health Reporting*, DOE Order 231.1A, U.S. Department of Energy, Washington, DC, August 2003.

LLNL (latest revision-a), *Environment, Safety, and Health Manual*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-133867, latest revision.

LLNL (latest revision-b), *LLNL Integrated Safety Management System Description*, Livermore, CA, UCRL-AR-132791, latest revision.

LLNL (latest revision-c), *LLNL Emergency Plan*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-MA-113311, latest revision.

LLNL (latest revision-d), *Radioactive and Hazardous Waste Management Division Quality Assurance Plan*, Lawrence Livermore National Laboratory, Livermore, CA, M-078-92, latest revision.

LLNL (latest revision-e), *Training Implementation Matrix for the Radioactive and Hazardous Waste Management Division*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-116655, latest revision.

LLNL (latest revision-f), *RHWM Nuclear Facility Configuration Management Program*, Lawrence Livermore National Laboratory, Livermore, CA, UCRL-AR-151576, latest revision.

NNSA/LLNS (2007), *Management and Operating Contract between The US Department of Energy/National Nuclear Security Administration and Lawrence Livermore National Security*, No. DE-AC52-07NA27344, effective October 1, 2007.

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APPENDIX A
PROCESS HAZARD ANALYSIS

The process hazard analysis (PrHA) is derived from an evaluation of hazards in the RHWM Waste Storage Facilities. The following acronyms are used in the PrHA tables:

Process Hazard ID Numbers:
WH = Waste Handling and Operations
DFA = Inadvertent Firearm Discharge, DWTF Storage Area
AFA = Inadvertent Firearm Discharge, Area 625
EE = External Event
NPH = Natural Phenomenon Hazard

Subject:
W = Worker
P = Public

Frequency:
A = Anticipated
U = Unlikely
EU = Extremely Unlikely
BEU = Beyond Extremely Unlikely

Consequence:
H = High
M = Moderate
L = Low

Risk:
I = High
II = Moderate
III = Low
IV = Negligible

Control Type/controls:
PA = Preventive Administrative
PE = Preventive Engineering
MA = Mitigative Administrative
ME = Mitigative Engineering

Table A-1. Global Notes and Assumptions Related to Process Hazards Analysis

1.	Throughout the PrHA tables, one * indicates an initial assumption; two ** indicates that the control is a significant contributor in reducing the frequency or consequence. These initial assumptions and controls are considered candidates for designation as Administrative Controls in the TSR.
2.	In the "Risk" columns of the PrHA tables, "W" denotes risk to the site facility worker or the co-located worker, whichever has the greater potential consequence, and "P" denotes risk to the public.
3.	Unless otherwise specified, accident scenarios assume waste is TRU waste or mixed TRU waste. TRU waste contains alpha-emitting transuranic elements with half-lives of greater than 20 years and a combined activity of 100 nanocuries per gram of waste. LLW is any radioactive waste not classified as either TRU or high-level; thus, any releases of solid or liquid LLW are bounded by similar TRU waste scenarios. Activities relative to high-level waste are not performed at LLNL.
4.	Mixed TRU waste contains RCRA hazardous material. The predominant hazard is radiological material.
5.	The following radiological hazards are assumed to be present in the waste: contaminated material and radioactive material.
6.	Non-radioactive hazardous materials may be present. Work requires Personal Protective Equipment and compliance with the requirements of the LLNL Hazardous Material Protection Program (*ES&H Manual*). These are required controls and for all mitigated cases are assumed to be established and implemented in all activities.
7.	Container inventories for hazardous waste chemicals are managed through the SCIL Program. Single container inventory limits are set at the ES&H Manual Document 3.1 Q values that result in consequences of TEEL-2 at 100 m. However, most containers have quantities well-below these limits. RHWM chemical inventory reviews have shown that releases from less than 1% of containers of hazardous waste chemicals could result in consequences >TEEL-1 and ≤TEEL-2 at 100 m; more than 99% would result in consequences ≤ TEEL-1. Typical releases result in small spills that do not release the entire contents of a container.
8.	Per sections 4.5.1.1 and 5.5.1 of this DSA, the assumed container inventory for TRU waste is 50 PE-Ci Ci if that limit does not yield consequences exceeding the NEPA bounding consequence calculations. The scenarios whose quantities are specifically constrained by NEPA calculations are aircraft crash scenarios with a fire. The fissile material inventory per container is also limited to 200 Pu-239 FGE.
9.	Emergency response is assumed as a control for all radioactive material release scenarios.
10.	Common mode failures are considered in this PrHA. Mitigation relies on human performance (e.g., training, evacuation) rather than SSCs. Interactions are considered and evaluated.
11.	Impacts to the environment from the scenarios are considered less than impacts to the public. As such, controls identified in the PrHA are considered sufficient to address impacts to the environment. In addition, secondary containment for liquid waste provides control to protect the environment.
12.	Storage of TRU waste no closer than 130 m from the site boundary was established as an initial condition for the hazard analysis.

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
Waste Handling & Operations																
WH-1	Spill	Driver loses control and vehicle collides with staged TRU waste containers causing a minor spill of waste and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Maintenance Testing & Inspection (MT&I) (vehicle) PA – Traffic controls	A	L	L	III	III	
WH-1A	Spill	Driver loses control and vehicle collides with an array of staged TRU waste containers in yard causing a significant spill of waste and release of radioactive material.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	U	L	M	III	II	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Maintenance Testing & Inspection (MT&I) (vehicle) PA – Traffic controls**	EU	L	M	IV	III	This scenario carried forward to accident analysis for further evaluation.

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-2	Spill	A pallet of TRU waste containers falls (greater than 4 feet) while loading a truck or stacking containers in the yard or in a building causing a minor spill and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	A	L	L	III	III	
WH-2A	Spill	A pallet of TRU waste containers falls (greater than 4 feet) while loading a truck or stacking containers in the yard or in a building causing a significant spill and release of radioactive material.	200	MA – Inventory controls* PE – Approved container*	U	L	M	III	II	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Certified forklift operator** PA – MT&I (forklift)	EU	L	M	IV	III	This scenario bounded and represented by WH-1A. Vehicle impact energy is not present, thus lower quantities of waste would be expelled. This leads to a smaller source term compared to a vehicle impact scenario.
WH-3	Spill	One TRU waste container falls (greater than 4 feet) while loading a truck or stacking containers causing a spill of waste and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	A	L	L	III	III	
WH-4	Spill	Forklift punctures or collides and breaches a TRU waste container.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	U	L	L	III	III	

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
WH-5	Spill	Pressurized cylinder containing gas or liquefied gas breaches releasing hazardous material or creates a projectile that impacts a staged TRU waste container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response	EU	L	L	IV	IV	
WH-6	Spill	Containers of waste with up to 2,000 Ci of tritium in each container are damaged causing a release of tritium gas or tritium oxide (HTO). Damage is due to a fall of containers or a pallet, or by a forklift puncture or projectile puncture.	8,000 (tritium)	MA – Inventory controls*	U	L	L	III	III	PA – Certified forklift operator PA – MT&I (forklift)	U	L	L	III	III	The MAR is in Curies of tritium, not PE-Ci.
WH-7	Spill	Small hazardous chemical spill or release results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – Single Container Inventory Limit (SCIL)	A	L	L	III	III	MA – Emergency response	A	L	L	III	III	This event represents a small spill that does not release the entire contents of a container. The primary waste streams would be described as dilute industrial hazardous waste.

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
WH-7A	Spill	Hazardous chemical spill or release of containers containing quantities significantly less than the SCIL results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL	U	L	L	III	III	MA – Emergency response	U	L	L	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.
WH-7B	Spill	Hazardous chemical spill or release of containers containing quantities approaching or at the SCIL results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL*	EU	M	M	III	III	MA – Emergency response	EU	M	M	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin.

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-8	Fire	Driver loses control and vehicle collides with TRU waste containers causing a minor spill of waste, fuel spills and ignites, and results in a burning release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – MT&I (vehicle) PA – Traffic controls	U	L	L	III	III	49 CFR 393 fuel tank design requirement restricts potential fuel spill. This scenario bounded and represented by DWTF WH-8A.
WH-8A	Fire	Driver loses control and vehicle collides with an array of staged TRU waste containers, breaching the array, causing a significant spill of waste, fuel spills and ignites, and results in a burning release of radioactive material.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – MT&I (vehicle) PA – Traffic controls	EU	L	M	IV	III	49 CFR 393 fuel tank design requirement restricts potential fuel spill.
WH-9	Fire	Forklift punctures TRU waste container and sparks ignite material in container.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	ME – Fire suppression system MA – Emergency response PA – MT&I (forklift) PA – Certified forklift operator	U	L	L	III	III	Fire suppression systems in B693 and B696R. This scenario bounded and represented by DWTF WH-8A.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-10	Fire	Incidental flammable liquid spill inside in conjunction with welding or other hot works ignition, or electrical short ignition source in the area, ignites combustibles or flammables, and engulfs TRU waste containers. A total of 10 containers with 50 PE-Ci each are at risk.	500	MA – Inventory controls* PE – Approved container*	EU	L	M	IV	III	ME – Fire suppression system MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked MA – Combustible loading program PA – MT&I PA – Hot Work Permit PA – Metal containers/ metal pallets	EU	L	M	IV	III	Fire suppression systems in B693 and B696R. This scenario is carried forward to accident analysis for further evaluation. Source term development in accordance with WM/FS-WSF-0404.
WH-11	Fire	Welding or other hot works ignition, or electrical equipment short or other ignition source in the area, ignites combustibles or flammables, and impacts a pallet of TRU waste containers.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	U	L	M	III	II	ME – Fire suppression system MA – Combustible loading program MA – Emergency response PA – Hot Work Permit PA – Metal containers/ metal pallets**	EU	L	M	IV	III	Fire suppression systems in B693 and B696R.This scenario represented and bounded by the consequences of WH-10. WH-10 is carried forward for further evaluation due to its similarity to this scenario and its greater MAR.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-12	Fire	Vehicle accidents, flammable liquid spills, or hot work ignites flammables or combustibles, fire engulfs up to 10 containers of waste containing 2,000 Ci each of tritium are impacted.	20,000 (tritium)	MA – Inventory controls*	U	L	L	III	III	ME – Fire suppression system MA – Emergency response PA – MT&I (vehicle) PA – Traffic controls PA – MT&I (forklift) PA – Certified forklift operator	U	L	L	III	III	The MAR is in Curies of tritium, not PE-Ci. Fire suppression systems in B693 and B696R. This scenario is carried forward to accident analysis since tritium is a unique hazard. Source term development in accordance with WM/FS-WSF-0401.
WH-13	Fire	Small hazardous chemical spill or release results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	A	L	L	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	A	L	L	III	III	This event represents a small spill that does not release the entire contents of a container. The primary waste streams would be described as dilute industrial hazardous waste. Fire suppression systems in B693 and B696R.

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
WH-13A	Fire	Hazardous chemical spill or release of containers containing quantities significantly less than the SCIL results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	U	L	L	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	U	L	L	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1. Fire suppression systems in B693 and B696R.
WH-13B	Fire	Hazardous chemical spill or release of containers containing quantities approaching or at the SCIL results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL*	EU	M	M	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	EU	M	M	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin. Fire suppression systems in B693 and B696R.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-14	Deflagra-tion	Ignition of flammable gas in an unvented waste container resulting in deflagration and release of radioactive materials.	50	MA – Inventory controls* PE – Approved container*	U	M	L	II	III	MA – Emergency response PA – TRU waste container maintenance program**	EU	M	L	III	IV	This scenario carried forward to accident analysis for further evaluation. The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low for the worker, which is consistent with the effects of a spill event.

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-15	Deflagra-tion	Ignition of flammable gas in a vented waste container resulting in deflagration and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	EU	M	L	III	IV	MA – Emergency response PA – TRU waste container maintenance program	EU	M	L	III	IV	The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low for the worker, which is consistent with the effects of a spill event.
WH-16	Criticality	Containers exceed the radionuclide fissile material limit, moderator/ reflector limits and/or configuration controls and criticality occurs.	> mass limits	MA – Inventory controls*	EU	H	L	II	IV	MA – Emergency response PA – Criticality Safety Program**	BEU	H	L	III	IV	Scenario not carried forward to accident analysis since there is only negligible risk to the public.
WH-17	Spill	During crane operation, drops load or load strikes and breaches TRU waste container.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified crane operator PA – MT&I (crane)	A	L	L	III	III	
WH-18	Spill	Crane boom strikes or drops load and breaches TRU waste containers.	200	MA – Inventory controls* PE – Approved container*	U	L	M	III	II	MA – Emergency response PA – Certified crane operator** PA – MT&I (crane)	EU	L	M	IV	III	

DWTF Storage Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
Inadvertent Firearm Discharge																
DFA-1	Spill	Firearm carried by security personnel inadvertently discharges striking and breaching a TRU waste container.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	PA – Security controls PE – Security controls MA – Emergency response	U	L	L	III	III	LLNL security requirements forbid workers from bringing firearms into facility. Armed security personnel are not assigned to the facility and rarely visit facility. Inadvertent firearm discharge caused by operator error, equipment malfunction or failure.
DFA-2	Spill	Firearm carried by security personnel inadvertently discharges striking a pressurized cylinder containing gas or liquefied gas; breaching cylinder and releasing hazardous material or creates a projectile that impacts a staged TRU waste container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	BEU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	BEU	L	L	IV	IV	See DFA-1. Release of flammable gas and subsequent fire is considered beyond extremely unlikely due to infrequent welding operations and knowledge of historical industrial welding accidents and the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
DFA-3	Spill	Firearm carried by security personnel inadvertently discharges striking containers of waste with up to 2,000 Ci of tritium in each container; containers are damaged causing a release of tritium gas or tritium oxide (HTO). Damage is due to container puncture.	2,000 (tritium)	MA – Inventory controls*	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See DFA-1. The MAR is in Curies of tritium, not PE-Ci.
DFA-4	Spill	Firearm carried by security personnel inadvertently discharges striking containers of hazardous chemical resulting in spill or release of material from container containing quantities significantly less than the SCIL, results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – Single Container Inventory Limit (SCIL)	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See DFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
DFA-5	Spill	Firearm carried by security personnel inadvertently discharges striking containers of hazardous chemical resulting in spill or release from container containing quantities approaching or at the SCIL, results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL*	BEU	M	M	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	BEU	M	M	IV	IV	See DFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA.
DFA-6	Fire	Firearm carried by security personnel inadvertently discharges striking TRU waste container and sparks ignite material in container.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See DFA-1. This scenario bounded and represented by DWTF WH-8A.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
DFA-7	Fire	Firearm carried by security personnel inadvertently discharges causing a hazardous chemical spill or release from container containing quantities significantly less than the SCIL, results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Combustible loading program MA – Emergency response	EU	L	L	IV	IV	See DFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
DFA-8	Fire	Firearm carried by security personnel inadvertently discharges causing a hazardous chemical spill or release from container containing quantities approaching or at the SCIL, results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL*	BEU	M	M	IV	IV	PA – Security controls PE – Security controls MA – Combustible loading program MA – Emergency response	BEU	M	M	IV	IV	See DFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA.

DWTF Storage Facilities																
ID No.	**Hazard**	**Scenario/MAR**	**MAR (PE-Ci)**	**Initial Conditions**	**Unmitigated**					**Control Type/Control**	**Mitigated**					**Comments**
					Freq.	**Consq.**		**Risk**			**Freq.**	**Consq.**		**Risk**		
						W	**P**	**W**	**P**			**W**	**P**	**W**	**P**	
DFA-9	Deflagration	Firearm carried by security personnel inadvertently discharges, striking an unvented TRU waste container causing ignition and resulting in deflagration and release of radioactive materials.	50	MA – Inventory controls* PE – Approved container*	EU	M	L	III	IV	PA – Security controls PE – Security controls MA – Emergency response MA – TRU waste container maintenance program	EU	M	L	III	IV	See DFA-1. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA. The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program that minimizes the potential for hydrogen accumulation. The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low for the worker, which is consistent with the effects of a spill event.

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
DFA-10	Fire	Site Security Issue. Damage with TRU waste present in drums.	264 PE-Ci	MA – Inventory controls* PE – Startup Sequence	BEU	H	M	III	IV	PA – Training PA – Procedures	BEU	H	M	III	IV	If B696R were full (bounding case) it could present 22 drums in a straight line from one end of the facility to another. All of these drums are assumed to experience shock-impact followed by localized fires. This involves a total of 264 PE-Ci, which would be bounded by the fire involving 500 PE-Ci analyzed in WH-10.
DFA-11	Spill	Site Security Issue. Damage with chemicals entrained in waste.	N/A	MA – SCIL* PE – Startup Sequence	BEU	H	L	III	IV	PA – Training PA – Procedures	BEU	H	L	III	IV	Small release potential.
External Events																
EE-1	Spill	Small aircraft crashes into staged TRU waste containers causing spill.	200	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response	EU	L	L	IV	IV	Source term development in accordance with HC/AB-B696-0302.

DWTF Storage Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
EE-2	Fire	Small aircraft crashes into facility causing a spill of waste, gasoline fuel spills and ignites, and release of radioactive material.	N/A	MA – Inventory controls* PE – Approved container*	BEU	M	M	II	IV	MA – Emergency response	BEU	M	M	IV	IV	Per the NEPA bounding source term of 0.925 PE-Ci, this MAR corresponds to 45 contiguous drums all loaded to 12 PE-Ci. Individual drum loadings in that configuration may increase if other drum loadings decrease so that the NEPA bounding source term limit is not exceeded. (See Section 3.4.2.6.2) Source term and consequence estimated in accordance with HC/AB-B696-0302 and WM/FS-WSF-0403. Effects to facility workers are evaluated at a stand-off distance; those close to the event will be killed by the physical effects of the crash and subsequent fire.

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
EE-3	Fire	Fire (e.g., from propane explosion) external to the facilities impacting TRU waste in the area leading to a radioactive release.	200/ pallet or array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response PA – Keep Clear Area** PE – Building structure	EU	L	M	IV	III	This scenario bounded by EE-2 (aircraft crash with fire). Impact energy is not present (or is less than aircraft crash scenario) to breach a drum, thus significant quantities of waste would not be expelled. This leads to a smaller source term compared to an impact scenario. Fire suppression systems in B693 and B696R.
EE-4	Spill	Accident (e.g., explosion) at nearby facility releases hazardous material or creates a projectile that impacts a staged TRU waste container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response PA – Keep Clear Area	EU	L	L	IV	IV	Projectiles from accidents at nearby facilities either cannot reach the area or missile velocity is minimal.
EE-5	Fire	Natural gas line breaches causing a fire within the area that impacts arrays of TRU waste containers.	200/ array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency response ME – Fire suppression system	EU	L	M	IV	III	Fire suppression systems in B693 and B696R. This scenario bounded by EE-2 (aircraft crash with fire). Natural gas line underground is capped off.

DWTF Storage Facilities																	
ID No.	**Hazard**	**Scenario/MAR**	**MAR (PE-Ci)**	**Initial Conditions**	**Unmitigated**					**Control Type/Control**	**Mitigated**					**Comments**
					Freq.	**Consq.**		**Risk**			**Freq.**	**Consq.**		**Risk**		
						W	**P**	**W**	**P**			**W**	**P**	**W**	**P**	
Natural Phenomena Hazards																	
NPH-1	Spill	High wind (up to 72 mph) impacts building and yard, wind causes TRU waste containers to fall.	200/ pallet	MA – Inventory controls* PE – Approved container* PE – Building structure*	U	L	L	III	III	MA – Emergency response MA – TRU waste container stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked	U	L	L	III	III	High winds cause significant dispersion, which decreases consequences. Containers designed to withstand a drop from at least 4-ft without breaching. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program
NPH-2	Fire	Lightning strikes building structure, resulting in a fire, which impacts TRU waste containers, burning waste. MAR is based on a fully released pallet.	200/ pallet	PE – Approved container* PE – Building structure*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency response ME – Fire suppression system PE – Building grounding system	EU	L	M	IV	III	Building structure is primarily non-combustible and is a grounded structure. Fire suppression systems in B693 and B696R.
NPH-3	Fire	Lightning strikes TRU waste container staged in yard, fire, waste released, burning waste. MAR is based on a fully released pallet.	200/ pallet or array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency response	EU	L	M	IV	III	

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
NPH-4	Spill	Heavy rains cause design basis flooding in buildings and yard areas.	200/ pallet	PE – Approved container*	U	L	L	III	III	MA – Emergency response	U	L	L	III	III	Heavy rains or flooding cause significant deposition, which decreases consequences.
NPH-5	Spill	Design basis earthquake impacts area causing containers to fall. MAR is based on a fully released pallet.	200/ pallet	PE – Approved container* PE – Building structure*	U	L	M	III	II	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked **	U	L	L	III	III	Vehicle impact energy is not present, thus lower quantities of waste would be expelled. This leads to a smaller source term compared to a vehicle impact scenario. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program

DWTF Storage Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
NPH-6	Fire	Design basis earthquake impacts facility, ignition source in the facility ignites combustibles (including ruptured natural gas line) and impacts TRU waste containers, burning waste. MAR is based on a fully released pallet.	200/ pallet or array	MA – Inventory controls* MA – Array limit* PE – Approved container* PE – Building structure*	U	L	M	III	II	ME – Fire suppression system MA – Combustible loading program** MA – Emergency Response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Metal containers/ metal pallets**	EU	L	M	IV	III	This scenario is brought forward into Section 3.4.3 Beyond Design Basis Accidents for evaluation. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program. Fire suppression systems in B693 and B696R.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
Waste Handling & Operations																
WH-1	Spill	Driver loses control and vehicle collides with staged TRU waste containers causing a minor spill of waste and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Maintenance Testing & Inspection (MT&I) (vehicle) PA – Traffic controls	A	L	L	III	III	

A625 Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-1A	Spill	Driver loses control and vehicle collides with an array of staged TRU waste containers in yard causing a significant spill of waste and release of radioactive material.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	U	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Maintenance Testing & Inspection (MT&I) (vehicle) PA – Traffic controls	U	L	L	III	III	This scenario bounded and represented by DWTF WH-1A.
WH-2	Spill	A pallet of TRU waste containers falls (greater than 4 feet) while loading a truck or stacking containers in the yard or in a building causing a minor spill of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	A	L	L	III	III	

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-2A	Spill	A pallet of TRU waste containers falls (greater than 4 feet) while loading a truck or stacking containers in the yard or in a building causing a significant spill and release of radioactive material.	200	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Maintenance Testing & Inspection (MT&I) (vehicle)	U	L	L	III	III	This scenario bounded by WH-1A and is represented by DWTF WH-1A. Vehicle impact energy is not present, thus lower quantities of waste would be expelled. This leads to a smaller source term compared to a vehicle impact scenario.
WH-3	Spill	One TRU waste container falls (greater than 4 feet) while loading a truck or stacking containers causing a spill of waste and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	A	L	L	III	III	
WH-4	Spill	Forklift punctures or collides and breaches TRU waste container.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response PA – Certified forklift operator PA – MT&I (forklift)	U	L	L	III	III	

A625 Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-5	Spill	Pressurized cylinder containing gas or liquefied gas breaches releasing hazardous material or creates a projectile that impacts a staged TRU waste container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response	EU	L	L	IV	IV	
WH-6	Spill	Small hazardous chemical spill or release results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – Single Container Inventory Limit (SCIL)	A	L	L	III	III	MA – Emergency response	A	L	L	III	III	This event represents a small spill that does not release the entire contents of a container. The primary waste streams would be described as dilute industrial hazardous waste.
WH-6A	Spill	Hazardous chemical spill or release of containers containing quantities significantly less than the SCIL results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL	U	L	L	III	III	MA – Emergency response	U	L	L	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-6B	Spill	Hazardous chemical spill or release of containers containing quantities approaching or at the SCIL results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL*	EU	M	M	III	III	MA – Emergency response	EU	M	M	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin.
WH-7	Spill	During crane operation, drops load or load strikes and breaches TRU waste container.	50	MA – Inventory controls* PE – Approved container*	A	L	L	III	III	MA – Emergency response PA – Certified crane operator PA – MT&I (crane)	A	L	L	III	III	
WH-8	Spill	Crane boom strikes or drops load and breaches TRU waste containers.	200	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response PA – Certified crane operator PA – MT&I (crane)	U	L	L	III	III	
WH-9	Spill	Containers of waste with up to 2,000 Ci of tritium in each container are damaged causing a release of tritium gas or tritium oxide (HTO). Damage is due to a fall of containers or a pallet, or by a forklift puncture or projectile puncture.	8,000 (tritium)	MA - Inventory Controls*	U	L	L	III	III	PA – Certified forklift operator PA – MT&I (forklift)	U	L	L	III	III	The MAR is in Curies of tritium, not PE-Ci

A625 Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
WH-10	Fire	Driver loses control and vehicle collides with staged TRU waste containers causing a minor spill of waste, diesel fuel spills and ignites, and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – MT&I (vehicle) PA – Traffic controls	U	L	L	III	III	49 CFR 393 fuel tank design requirement restricts potential fuel spill. This scenario bounded and represented by DWTF WH-8A.
WH-10A	Fire	Driver loses control and vehicle collides with an array of staged TRU waste containers causing a significant spill of waste, diesel fuel spills and ignites, and release of radioactive material.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – MT&I (vehicle) PA – Traffic controls	EU	L	M	IV	III	49 CFR 393 fuel tank design requirement restricts potential fuel spill. This scenario bounded and represented by DWTF WH-8A.
WH-11	Fire	Forklift punctures TRU waste container and sparks ignite material in container.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	ME – Fire suppression system MA – Emergency response PA – MT&I (forklift) PA – Certified forklift operator	U	L	L	III	III	Fire suppression system in B625. This scenario bounded and represented by DWTF WH-8A.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-12	Fire	Incidental flammable liquid spill inside in conjunction with welding or other hot works ignition, or electrical equipment short ignition source in the area, ignites liquid, and engulfs TRU waste containers. A total of 10 containers with 50 PE-Ci each are at risk.	500	MA – Inventory controls* PE – Approved container*	EU	L	M	IV	III	ME – Fire suppression system MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked MA – Combustible loading program PA – MT&I PA – Hot Work Permit PA – Metal containers/ metal pallets	EU	L	M	IV	III	Fire suppression system in B625. This scenario bounded and represented by DWTF WH-10. Source term development in accordance with WM/FS-WSF-0404.
WH-13	Fire	Welding or other hot works ignition, or electrical equipment short or other ignition source in the area ignites flammables or combustibles and impacts a pallet of containers.	200	MA – Inventory controls* MA – Array limit* PE – Approved container*	U	L	M	III	II	ME – Fire suppression system MA – Combustible loading program MA – Emergency response PA – Hot Work Permit PA – Metal containers/ metal pallets**	EU	L	M	IV	III	Fire suppression system in B625. This scenario bounded by WH-13 and is represented by DWTF WH-10. WH-13 bounds this scenario due to its similarity and its greater MAR.

A625 Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-14	Fire	Vehicle accidents, flammable liquid spills, or hot work ignites flammables or combustibles, fire engulfs up to 10 containers of waste containing 2,000 Ci each of tritium are impacted.	20,000 (tritium)	MA – Inventory controls*	U	L	L	III	III	ME – Fire suppression system MA – Emergency response PA – MT&I (vehicle) PA – Traffic controls PA – MT&I (forklift) PA – Certified forklift operator	U	L	L	III	III	The MAR is in Curies of tritium, not PE-Ci. Fire suppression system in B625. This scenario has a unique hazard that is bounded and represented by DWTF WH-13.
WH-15	Fire	Small hazardous chemical spill of release results in flammable vapor that ignites or pyrophoric reaction and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	A	L	L	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	A	L	L	III	III	This event represents a small spill that does not release the entire contents of a container. The primary waste streams would be described as dilute industrial hazardous waste. Fire suppression system in B625.
WH-15A	Fire	Hazardous chemical spill or release of containers containing quantities significantly less than the SCIL results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	U	L	L	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	U	L	L	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1. Fire suppression system in B625.

A625 Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-15B	Fire	Hazardous chemical spill or release of containers containing quantities approaching or at the SCIL results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL*	EU	M	M	III	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response	EU	M	M	III	III	This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin. Fire suppression system in B625.
WH-16	Deflagra-tion	Ignition of flammable gas in an unvented waste container resulting in deflagration and release of radioactive materials.	50	MA – Inventory controls* PE – Approved container*	U	M	L	II	III	MA – Emergency response PA – TRU waste container maintenance program**	EU	M	L	III	IV	The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program. The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low, which is consistent with the effects of a spill event.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
WH-17	Deflagra-tion	Ignition of flammable gas in a vented waste container resulting in deflagration and release of radioactive materials.	50	MA – Inventory controls* PE – Approved container*	EU	M	L	III	IV	MA – Emergency response PA – TRU waste container maintenance program	EU	M	L	III	IV	The TRU waste container maintenance program is an element of the In-service Inspection & Test (ISIT) Program The consequences to the worker are considered moderate if the worker is present. If a worker enters the scene after the event occurs, the consequences are considered low, which is consistent with the effects of a spill event.
WH-18	Criticality	Containers exceed the radionuclide fissile material limit, moderator/ reflector limits and/or configuration controls and criticality occurs.	> mass limits	MA – Inventory controls*	EU	H	L	II	IV	MA – Emergency response PA – Criticality Safety Program**	BEU	H	L	III	IV	Scenario not carried forward to accident analysis since there is only moderate risk to the public.

A625 Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated Freq.	Unmitigated Consq. W	Unmitigated Consq. P	Unmitigated Risk W	Unmitigated Risk P	Control Type/Control	Mitigated Freq.	Mitigated Consq. W	Mitigated Consq. P	Mitigated Risk W	Mitigated Risk P	Comments
Inadvertent Firearm Discharge																
AFA-1	Spill	Firearm carried by security personnel inadvertently discharges striking and breaching a staged TRU waste containers causing a minor spill of waste and release of radioactive material.	50	MA – Inventory controls* PE – Approved container*	U	L	L	III	III	PA – Security controls PE – Security controls MA – Emergency response	U	L	L	III	III	LLNL security requirements forbid workers from bringing firearms into facility. Armed security personnel are not assigned to the facility and rarely visit facility. Inadvertent firearm discharge caused by operator error, equipment malfunction or failure.
AFA-2	Spill	Firearm carried by security personnel inadvertently discharges striking a pressurized cylinder containing gas or liquefied gas; breaching cylinder, releasing hazardous material or creates a projectile that impacts a staged TRU waste container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	BEU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	BEU	L	L	IV	IV	See AFA-1. Release of flammable gas and subsequent fire is considered beyond extremely unlikely due to infrequent welding operations and knowledge of historical industrial welding accidents and the rare visits of armed security personnel to the facility.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
AFA-3	Spill	Firearm carried by security personnel inadvertently discharges striking containers of hazardous chemical resulting in spill or release of material from container containing quantities significantly less than the SCIL, results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – Single Container Inventory Limit (SCIL)	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See AFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
AFA-4	Spill	Firearm carried by security personnel inadvertently discharges striking containers of hazardous chemical resulting in spill or release from container containing quantities approaching or at the SCIL, results in a toxic atmospheric dispersal of chemical, no impact on TRU waste.	N/A	MA – SCIL*	BEU	M	M	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	BEU	M	M	IV	IV	LLNL security requirements forbid workers from bringing firearms into facility. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin.

A625 Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
AFA-5	Spill	Firearm carried by security personnel inadvertently discharges striking containers of waste with up to 2,000 Ci of tritium in each container are damaged causing a release of tritium gas or tritium oxide (HTO). Damage is due to container puncture.	2,000 (tritium)	MA – Inventory controls*	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See AFA-1. The MAR is in Curies of tritium, not PE-Ci.
AFA-6	Fire	Firearm carried by security personnel inadvertently discharges striking TRU waste container and sparks ignite material in container.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Emergency response	EU	L	L	IV	IV	See AFA-1. This scenario bounded and represented by DWTF WH-8A.
AFA-7	Fire	Firearm carried by security personnel inadvertently discharges causing a hazardous chemical spill or release from container containing quantities significantly less than the SCIL, results in flammable vapor that ignites and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL	EU	L	L	IV	IV	PA – Security controls PE – Security controls MA – Combustible loading program MA – Emergency response	EU	L	L	IV	IV	See AFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that more than 99% of containers released would result in consequences ≤TEEL-1.

A625 Facilities																	
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
AFA-8	Fire	Firearm carried by security personnel inadvertently discharges causing a hazardous chemical spill or release from container containing quantities approaching or at the SCIL, results in flammable vapor that ignites or pyrophoric reaction, and results in localized fire, no impact on TRU waste.	N/A	MA – SCIL*	BEU	M	M	IV	IV	PA – Security controls PE – Security controls MA – Combustible loading program MA – Emergency response	BEU	M	M	IV	IV	See AFA-1. This event represents a full release of container contents. The primary waste streams would be described as dilute industrial hazardous waste. Chemical inventory reviews demonstrate that less than 1% of containers released could result in consequences >TEEL-1 and ≤TEEL-2, which reduces the frequency of an accident by one bin. Release is considered beyond extremely unlikely since the initiator is a sufficiently small contributor to the frequencies already assumed for spill in the DSA

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
AFA-9	Fire	Site Security Issue. Damage with TRU waste present in drums.	264 PE-Ci	MA – Inventory controls* PE – Startup Sequence	BEU	H	M	III	IV	PA – Training PA – Procedures	BEU	H	M	III	IV	Assumes 22 drums in a straight line from one end of the facility to another. All of these drums are assumed to experience shock-impact followed by localized fires. This involves a total of 264 PE-Ci, which would be bounded by the fire involving 500 PE-Ci analyzed in DWTF WH-10.
AFA-10	Spill	Site Security Issue. Damage with chemicals entrained in waste.	N/A	MA – SCIL* PE – Startup Sequence	BEU	H	L	III	IV	PA – Training PA – Procedures	BEU	H	L	III	IV	Small release potential.
External Events																
EE-1	Spill	Small aircraft crashes into staged TRU waste containers causing spill.	200	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response	EU	L	L	IV	IV	Source term development in accordance with HC/AB-B696-0302.

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ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
EE-2	Fire	Small aircraft crashes into facility causing a spill of waste, gasoline fuel spills and ignites, and release of radioactive material.	N/A	MA – Inventory controls* PE – Approved container*	EU	M	M	III	III	MA – Emergency response	EU	M	M	III	III	Per the NEPA bounding source term of 1.4 PE-Ci, this MAR corresponds to 45 contiguous drums all loaded to 18 PE-Ci. Individual drum loadings in that configuration may increase if other drum loadings decrease so that the NEPA bounding source term limit is not exceeded. (See Section 3.4.2.6.2) This event is credible and thus carried forward to accident analysis Source term and consequence estimation in accordance with HC/AB-B696-0302 and WM/FS-WSF-0403. Effects to facility workers are evaluated at a stand-off distance; those close to the event will be killed by the physical effects of the crash and subsequent fire.

A625 Facilities

ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
EE-3	Fire	Fire external to the area (e.g. refueling fire, from propane explosion) impacting TRU waste in the area leading to a radioactive release.	200/ pallet or array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response PA – Keep Clear Area** PE – Building structure	EU	L	M	IV	III	This scenario bounded by EE-2 (aircraft crash with fire). Impact energy is not present (or is less than aircraft crash scenario) to breach a drum, thus significant quantities of waste would not be expelled. This leads to a smaller source term compared to an impact scenario. Fire suppression systems in B625.
EE-4	Spill	Accident (e.g., explosion) at nearby facility releases hazardous material or creates a projectile that impacts a staged container resulting in a spill.	50	MA – Inventory controls* PE – Approved container*	EU	L	L	IV	IV	MA – Emergency response PA – Keep Clear Area	EU	L	L	IV	IV	Projectiles from accidents at nearby facilities either cannot reach the area or missile velocity is minimal.
EE-5	Fire	Natural gas line breaches causing a fire within the area that impacts pallets of TRU waste containers.	200/ array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency response ME – Fire suppression system	EU	L	M	IV	III	Fire suppression system in B625. This scenario bounded by EE-2 (aircraft crash with fire). Natural gas lines are capped off.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
EE-6	Fire	High voltage power line falls into yard and initiates a fire impacting TRU waste containers staged in yard.	200/ array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency Response	EU	L	M	IV	III	This scenario bounded by EE-2 (aircraft crash with fire). Impact energy is not present to breach a drum, thus significant quantities of waste would not be expelled. This leads to a smaller source term compared to an impact scenario.
Natural Phenomena Hazards																
NPH-1	Spill	High wind (up to 72 mph) impacts building and yard, wind causes TRU waste containers to fall.	200/ pallet	MA – Inventory controls* PE – Approved container* PE – Building structure*	U	L	L	III	III	MA – Emergency response MA – TRU waste container stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked	U	L	L	III	III	High winds cause significant dispersion, which decreases consequences. Containers designed to withstand a drop from at least 4-ft without breaching. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
NPH-2	Fire	Lightning strikes building structure, resulting in a fire, which impacts TRU waste containers, burning waste. MAR is based on a fully released pallet.	200/ pallet	PE – Approved container* PE – Building structure*	EU	L	M	IV	III	ME – Fire suppression system MA – Combustible loading program MA – Emergency response ME – Fire sprinkler system PE – Building grounding system	EU	L	M	IV	III	Building structure is primarily non-combustible and is a grounded structure. Fire suppression system in B625.
NPH-3	Fire	Lightning strikes TRU waste container staged in yard, fire, waste released, burning waste. MAR is based on a fully released pallet.	200/ pallet or array	MA – Inventory controls* MA – Array limit* PE – Approved container*	EU	L	M	IV	III	MA – Combustible loading program MA – Emergency Response	EU	L	M	IV	III	
NPH-4	Spill	Heavy rains cause design basis flooding in buildings and yard areas.	200/ pallet	PE – Approved container*	U	L	L	III	III	MA – Emergency response	U	L	L	III	III	Heavy rains or flooding cause significant deposition, which decreases consequences.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
NPH-5	Spill	Design basis earthquake impacts facilities causing containers to fall. MAR is based on a fully released pallet.	200/ pallet	PE – Approved container* PE – Building structure*	U	L	M	III	II	MA – Emergency response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked **	U	L	L	III	III	Vehicle impact energy is not present, thus lower quantities of waste would be expelled. This leads to a smaller source term compared to a vehicle impact scenario. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program. B625 crane has seismic restraints.

A625 Facilities																
ID No.	Hazard	Scenario/MAR	MAR (PE-Ci)	Initial Conditions	Unmitigated					Control Type/Control	Mitigated					Comments
					Freq.	Consq.		Risk			Freq.	Consq.		Risk		
						W	P	W	P			W	P	W	P	
NPH-6	Fire	Design basis earthquake impacts facility, ignition source in the facility ignites combustibles (including ruptured natural gas line) and impacts a pallet of containers. MAR is based on a fully released pallet.	200/ pallet	MA – Inventory controls* PE – Approved container* PE – Building structure*	U	L	M	III	II	ME – Fire suppression system MA – Combustible loading program** MA – Emergency Response MA – TRU waste containers stacked no more than 2 high; containers exceeding nominal height of 4-ft not stacked PA – Metal containers/ metal pallets**	EU	L	M	IV	III	This scenario is brought forward into Section 3.4.3 Beyond Design Basis Accidents for evaluation. Building structures that meet PC-2 requirements are inspected using the In-service Inspection & Test (ISIT) Program. Fire suppression systems in B625.

APPENDIX B
AIRCRAFT CRASH ANALYSIS

The probability of an aircraft crashing into waste storage facilities was evaluated using the methods described in DOE-STD-3014-96. The probability of an aircraft crash is evaluated to bound the risk presented by surrounding airports and types of aircraft and operations in those airports. An assessment for Building 332 ("Aircraft Crash Probability analysis for Building 332 at LLNL," K. Foote, 2003) showed that general aviation associated with the Livermore Municipal Airport (LVK) accounted for approximately 90% of the aircraft crash probability. Therefore, the operations of general aviation aircraft at the Livermore Municipal Airport dominate the risk of an aircraft crash to facilities at LLNL. Hence, the scope of this analysis is limited to quantification of the risk from general aviation at LVK.

B.1 Screening aircraft crash probability

The analysis of the aircraft crash probability does not take into account the surrounding structures, and includes the probability that a wing tip of a light aircraft nicks a building (refer to Figure B-3 in DOE-STD-3014-96), which would not lead to uncontrolled radioactive release. Hence, the probability of an aircraft crash obtained by the analysis is conservative even without the adjustment for other types of aircrafts.

The formula below was used to calculate the frequency of an aircraft crash into the waste storage facilities:

$$F = \sum_i N_i P_i f_i(x, y) A_i$$

where F is the estimated annual aircraft crash impact frequency for the facility, N is annual number of aircraft operations, P is the aircraft crash rate (crash/operations), $f(x,y)$ is the aircraft crash location conditional probability (mi^{-2}), A is the effective area of (mi^2), and i is the flight phase, i.e., takeoff, in-flight, and landing.

The total number of aircraft operations is on the order of 240,000 per year from the latest posting on the Livermore Municipal Airport web site. The operations are all conservatively assumed to be general aviation of the fixed wing single engine reciprocating type. The distance from the middle of the runway to the nearest corner of a waste storage facility is approximately 6.6 miles. From Table B-1 of DOE-STD-3014-96, the generic crash rates are 1.1×10^{-5} per takeoff and 2.0×10^{-5} per landing, respectively. The crash location conditional probabilities, values of $f(x, y)$, for landings and take-offs in Tables B-4 and B-5 in DOE-STD-3014-96 are 2.9×10^{-3} and 0, respectively. In the opposite direction, associated crash location probabilities are 6.5×10^{-4} and 1.5×10^{-3}, respectively.

The effective target area presented is calculated using Equations B-3 to B-5 in DOE-STD-3014-96. Together, these equations yield the following:

$$A_{eff} = (WS + R)(S + H \cot\phi) + \left(\frac{2 \times WS}{R} + 1\right) L \times W$$

where *WS* is the aircraft wing span, *R* is the length of facility diagonal, *S* is the aircraft skid distance, *H* is the facility height, $cot\varphi$ is the cotangent of aircraft impact angle, *L* is the length of facility, and *W* is the width of facility.

Dimensions of the buildings are provided in Table B-1. The wingspan of a general aviation aircraft is 50 ft from Table B-16 of DOE-STD-3014-96. For general aviation, the value of $cot\varphi$ is 8.2 from Table B-17 and the skid distance is 60 ft from Table B-18 in DOE-STD-3014-96. The calculated effective target area is shown in **Table B-1**.

Table B-1. General Facility Dimensions and Effective Area.

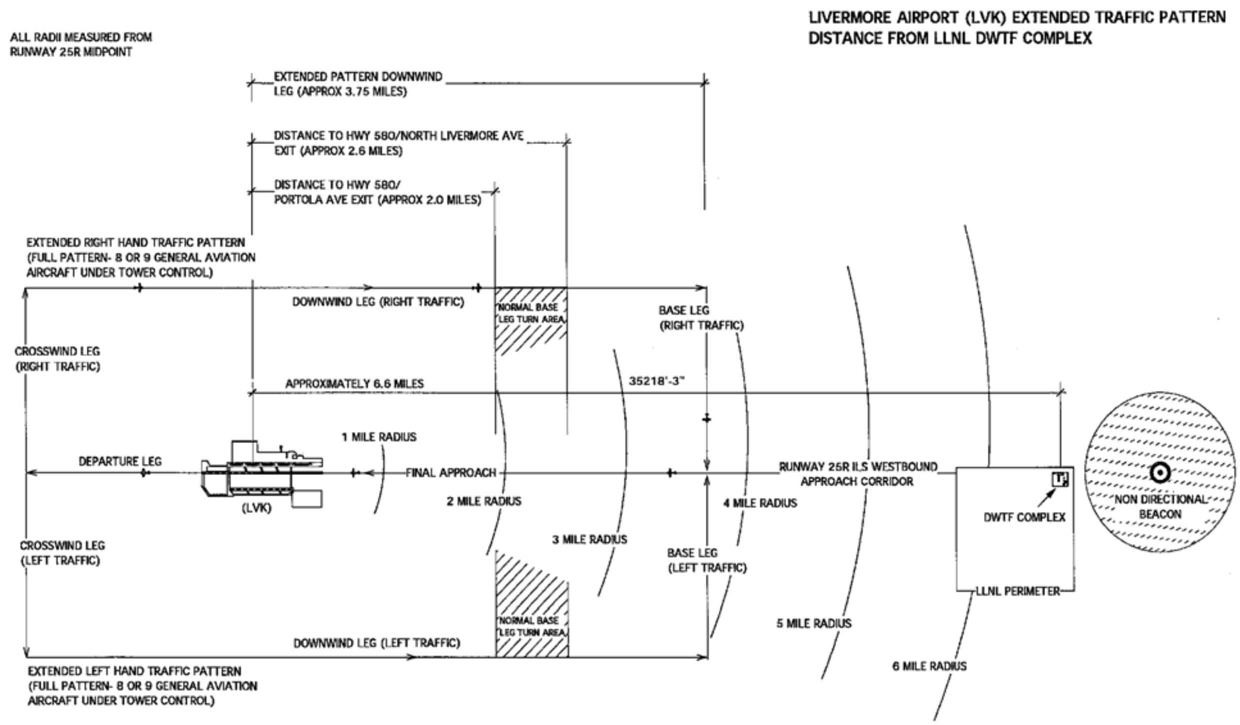
Facility	Length (ft)	Width (ft)	Height (ft)	Diagonal (ft)	Effective Area (mi^2)
B625	120	40	24	126.5	1.9×10^{-3}
T6197	82	49	16	95.5	1.3×10^{-3}
T6198	98	30	16	102.5	1.3×10^{-3}
B693*	150	80	16	170.0	2.2×10^{-3}
B696R	120	80	23	144.2	2.3×10^{-3}

* Historically calculated value, TRU waste is no longer authorized for B693 by this DSA.

LVK is a Class D airport without the practice area. The traffic pattern extends approximately 4 miles from the runway at LVK. It is extended in a mile increment during periods of unusual air traffic congestion. Periods of unusually heavy congestion, when the traffic pattern is extended toward LLNL, occur infrequently. In those periods of congestion, aircraft are often required to (1) perform full stop landings, (2) exit the active runway and taxi back to the original departure position, and then (3) resume flight activities by requesting control tower access to the active runway prior to departure. When this happens, it changes the activity category from “touch and go” to the normal landing and takeoff. These are then included in the number of itinerant operations not associated with local operations within the traffic pattern.

This is further supported by the FAA regulatory language that addresses airspace boundaries in the pattern around airports in FAA Order 7400.2E, “Procedures for Handling Airspace Matters,” Change 1, July 7, 2001. In Section 10.3-2, “Airport Spacing Guidelines and Traffic Pattern Airspace Areas,” a full pattern in the airspace around Livermore, which consists of eight to nine aircraft in the pattern, extends downwind about 3.75 miles from the center of Runway 25R only a portion of the time when the predominant wind direction is from the west. This puts the turn into the base leg about 2.75 miles away from the Building 696. Anecdotal reports from flight instructors at LVK indicate that the majority of the time they make this turn (downwind to base leg) over the Portola Avenue exit from Highway 580. Relative positions of LVK, LLNL, and the extended pattern are illustrated in Figure B-1.

Figure B-1. Extended Traffic Pattern for Livermore Airport (LVK)



The estimate of effective area is made assuming the facility is a rectangle with the aircraft approaching perpendicular to the diagonal of the building. DOE-STD-3014 recognizes that these assumptions provide a conservative approximation to the true effective area.

A large portion of the operations is from local operations that include "touch and go" at the airport for flight training. Because local operations are typically confined to the 4-mi radius from the airport and do not go over or near the LLNL, these are excluded from the crash probability calculation. For conservatism, an additional 10% was assumed for non-counted general aviation operations that occur outside airport control tower operational times.

Then, a total of 94,100 operations at the Livermore Municipal Airport are itinerant operations. Including a 10% margin for non-counted general aviation operations, 104,000 operations are assumed for the crash probability analysis. For simplicity, operations in each direction are assumed to be divided evenly between takeoff and landing. Also, there is a directional dependence for landing and takeoff because of the prevailing wind at the Livermore Municipal Airport. Approximately 82% of the flights take off and land in the east-west direction. Based on DOE-STD-3014-96, the calculated annual probability of an itinerant aircraft crash into a waste storage facility is presented in Table B-2. For outdoor staging, a representative array of TRU waste containers that is two pallets wide (18 ft, includes 10 ft spacing), four pallets long (16 ft), and two pallets high (10.25 ft, conservatively assumed) would have an annual itinerant aircraft impact frequency of approximately 1.2×10^{-6} for general aviation aircraft. Staged pallets have a lower aircraft impact frequency than a facility with an equivalent footprint because the height of the double-stacked containers is less than the height of a facility.

Table B-2. Annual Itinerant Aircraft Impact Frequencies for Waste Storage Facilities

Facility	General Aviation
B625	5.3×10^{-6}
T6197	3.5×10^{-6}
T6198	3.4×10^{-6}
B693*	6.0×10^{-6}
B696R	6.3×10^{-6}

* Historically calculated value, TRU waste is no longer authorized for B693 by this DSA.

B.2 Better-estimate of aircraft crash probability leading to uncontrolled release of radioactivity for B696R

The annual crash probability must also be limited to that which results in a direct impact on TRU waste drums in Building 696R. If the crash location is at the top or the roof of the building at a shallow angle, the engine is not expected to affect the TRU waste drums. For example, using the 7° impact angle for general aviation aircrafts from DOE-STD-3014-96, if the general aviation aircraft hits the top corner of the building, it requires 189 ft to reach the ground. A longer distance would be required for shallower impact angles. In comparison, the length of Building 696R is 120 ft. This indicates that the annual crash probability includes that which results in a damage to the building without any radioactive release. Therefore, the profile must be adjusted to that of the stored TRU waste drums for the potential radioactive release from TRU waste drums. For conservatism, the height of the stored drums is assumed to be 10.25 ft, which would exceed the height of stacked TRU waste containers.

The integrity of structural members for Building 696R was evaluated in Reference 1 (WM/WT-B696-0201). These structural members are part of the safety-significant SSC, the B696R structure, as described in Section 4.4.2.2. The evaluation showed that a direct vertical impact by the engine of a general aviation aircraft on the most vulnerable roof beam at the point of maximum deflection in Building 696R would result in yielding, but not catastrophic failure leading to a collapse, of the roof beam. The same would apply to the structural columns of the walls of Building 696R. Structural columns are placed 20 ft apart on the east wall and are 30 ft apart on the north and south walls (see Figure 1, WM/WT-B696-0201). The potentially vulnerable area is then limited to the spacing between the structural members minus the width of the solid fragments.

Structural members are typically W18×35. The width of column flanges are 8-in. A typical reciprocating piston engine has dimensions of 36-in×20-in. The effective length and width of the building are adjusted to account for the structural robustness as follows:

$$W_{eff} = 83\,\text{ft} \times \left[1 - \frac{3\left(24/12\right)\,\text{ft} + 2\left(16/12\right)\text{ft}}{83\,\text{ft}} \right]$$

$$= 74\,\text{ft}$$

The facility is 83-ft wide (east and west walls) with five 8-in wide structural columns that provide shielding capable of providing protection from debris or a missile. The effective width (Weff) was adjusted by considering that: the three columns distributed along the wall provided 24-in of protection when considering the 8-in column and that the center of the engine could be 8-in off either side of the center line of the column and still provide adequate shielding from the 20-in wide engine; and the two end columns would provide 16-in of protection since each is providing protection on one side of the column. This results in an adjusted effective width of 74-ft, as shown in the previous equation.

$$L_{eff} = 120\ \text{ft} \times \left[1 - \frac{3\left(24/12\right)\ \text{ft} + 2\left(16/12\right)\text{ft}}{120\ \text{ft}} \right]$$

$$= 111\ \text{ft}$$

The facility is 120-ft wide (north and south walls) with five 8-in wide structural columns that provide shielding capable of providing protection from debris or a missile. The effective width (Weff) was adjusted by considering that: the three columns in distributed along the wall provided 24-in of protection when considering the 8-in column and that the center of the engine could be 8-in off either side of the center line of the column and still provide adequate shielding from the 20-in wide engine; and the two end columns would provide 16-in of protection since each is providing protection on one side of the column. This results in an adjusted effective width of 111-ft, as shown in the previous equation.

There are additional K-bracings, shear support structural beams, to prevent shear failure in the event of an earthquake. These provide further protection against a potential plane crash by limiting the effective target area for penetration through the roof and walls. Ignoring the K-bracings, however, vulnerable width and length of Building 696R are approximately 111-ft×74-ft. As previously discussed, the wingspan is also reduced to 20 ft for the engine and a significant portion of the wings that contain fuel to penetrate through the walls or the roof between the structural beams. Upon impact with the ground, the aircraft will sustain structural damage. The debris could impact and penetrate the facility; however, the fuel would spread outside the facility and only a small quantity would follow the debris into the facility. Any resulting fire is assumed to not be sufficient to involve multiple drums in a sustained fire. It is not considered viable for an impact with the ground, with debris penetrating the facility, puncturing multiple TRU waste containers, and having a sustained fire resulting in a release to the environment. Therefore, the skid length is reduced to zero when computing the net target area for a fire.

Then, the net target area is reduced to:

$$
\begin{aligned}
A_{net} &= \left[(20+134)\times(0+10.25\times8.2)+\left(\frac{2\times20}{134}+1\right)\times111\times74 \right]\times(5280)^{-2} \\
&= 8.5\times10^{-4}\ \text{mi}^2
\end{aligned}
$$

Also, the angle of direct impact has a significant effect on the annual crash probability. For simplicity, the impact angle of 7°, the standard value for general aviation, is used to estimate the annual crash probability.

B696R is shielded by surrounding buildings and trees. DOE-STD-3014 allows consideration of nearby barriers in the calculation of the effective target area. B696S is attached to B696R on the west and is 12-ft taller than B696R. This allows B696S to shield B696R on the west and partially on the roof. B695 is southwest of B696R and B693 is south of B696R. Both of these buildings provide partial shielding for B696R from the south. It is estimated that the total shielding attributes would reduce the effective target area by approximately 20%. Thus, the annual crash probability is:

$$
\begin{aligned}
F &= \sum_i N_i P_i f_i(x,y) A_i \\
&= 2.75\times10^{-3}\times8.5\times10^{-4}\times(1-0.20) \\
&= 1.9\times10^{-6}
\end{aligned}
$$

Note: The factor 2.75×10^{-3} is the ratio of the crash probability computed in Table B-2 divided by the effective target area computed in Table B-1.

The annual probability of an aircraft crash leading to a direct impact with the TRU waste drum configuration required to produce the evaluated source term using the modified effective target area is 1.9×10^{-6}. The probability of an aircraft crash leading to a waste spill is therefore “extremely unlikely.”

The conditional probability of occurrence of a fire from a general aviation aircraft crash is approximately 0.3 (Wall 1974). The annual probability of an aircraft crash leading to a direct impact with the TRU waste drum configuration required to produce the evaluated source term with a fire involving the inventory of TRU waste containers is 6×10^{-7}. The conditional probability of a direct impact on the stacked drums all containing the maximum quantity of radioactivity is less than unity. Combining all factors together, the probability of the worst-case aircraft crash – a direct impact followed by a large fire involving drums, all of which contain the maximum radioactive inventory – leading to an uncontrolled release of a significant quantity of radioactivity is less than 6×10^{-7}, and is therefore “beyond extremely unlikely.”

Further, only a portion of the aircraft represents material that could damage an approved TRU waste container after initial impact with the ground or facility. Nondeformable debris comprises the rigid and heavy components (e.g., engine), could have sufficient energy to damage an approved TRU waste container after initial impact. Deformable debris comprises relatively soft components that absorb energy during impact (e.g., wings, fuselage) and is not anticipated to have sufficient energy to damage an approved TRU waste container after initial impact. Using a representative aircraft (e.g., Piper Saratoga II HP) involved in an accident, the engine represents the primary nondeformable debris for a single engine fixed gear aircraft. The aircraft has a maximum takeoff weight of 3,600 pounds and an engine weight of approximately 450 pounds (WM/WT-B696-0201). Doubling the engine weight to account for any additional components that could act as nondeformable debris (DOE-STD-3014), results in 25% of the mass of the aircraft considered as potential nondeformable debris with the potential to damage approved TRU waste containers and 75% of the mass of the aircraft not anticipated to have sufficient energy to damage approved TRU waste containers after initial impact. Fuel is stored in the deformable aircraft wings that are anticipated to disassociate upon impact. Thus, resulting in a significant quantity of the fuel remaining outside of the facility, and reducing the potential size and duration of a fuel fire. Taking these issues into consideration would reduce the potential for an aircraft crash resulting in a fuel fire involving the inventory of TRU waste containers, thus providing additional conservatism to this analysis.

B.3 Better-estimate of aircraft crash probability leading to uncontrolled release of radioactivity for B693

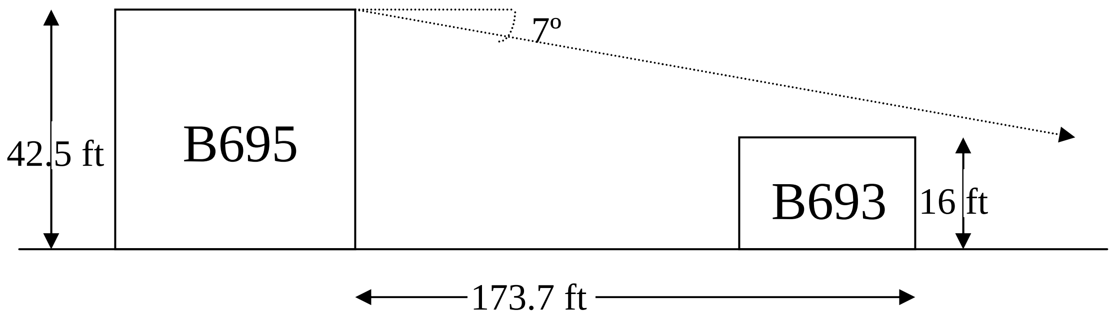
As part of this evaluation, a structural analysis of B693 was performed to identify if the structural capacity of the building would withstand the impact from an aircraft crash. The conclusion of the analysis was that the B693 structural system is not capable of withstanding the crash impulse load from a general aviation aircraft impact (Reference 3).

Section 3.4.3.3 provides an analysis of the consequences to the maximally exposed offsite individual (MOI) from a general aviation aircraft crash into B693 with an ensuing fire resulting in an uncontrolled radioactive release. The source term assumes that 45 TRU waste drums each containing 50 PE-Ci fail due to the impact or from the ensuring fire, resulting in both contained and uncontained burning of the contents. The radiation dose consequence to the MOI is estimated to be 15 rem TEDE.

In the Building 696R (B696R) crash estimation for aircraft crash probability factors such as shielding from nearby buildings, reduced skid length and structural deflection were considered in a better-estimate of the crash probability. For B693, only shielding from nearby buildings is valid. The reduced skid distance in the B696R evaluation is based on a small quantity of debris and fuel penetrating the building and that they would not be sufficient to involve multiple drums in a sustained fire.

However, B693 contains flammable liquid waste, which, in the event of an aircraft impact, will likely lead to a fire. Moreover, unlike the structural member integrity of B696R, the structural integrity of B693 is not assured in an impact. Therefore, only shielding is taken into consideration consistent with the methodology in DOE-STD-3014-96.

Of the buildings surrounding B693, only Building 695 (B695) is high enough to shield B693. Taking the impact angle of 7° for general aviation aircrafts from DOE-STD-3014-96, B695 shields the west side of B693 from an aircraft crash, as evaluated below.



Only the west side of B693 is shielded by B695. Assuming a constant height for B693 and taking the ratio of the length of the west side of B693 (150 m) to the total building perimeter (460 m), it is estimated that approximately 33% of the building is shielded by B695. Therefore, the effective area of B693 is reduced by approximately 33% in the annual crash probability calculation.

Thus, the annual crash probability is:

$$\begin{aligned} F &= \sum_i N_i P_i f_i(x,y) A_i \\ &= 6.0 \times 10^{-6} \times (1 - 0.33) \\ &= 4.0 \times 10^{-6} \end{aligned}$$

The annual probability of an aircraft crash leading to an impact is 4.0×10^{-6}. Therefore, the probability of the worst-case aircraft crash – a direct impact followed by a large fire involving drums, all of which contain the maximum radioactive inventory – leading to an uncontrolled release of a significant quantity of radioactivity is “extremely unlikely.”

Note again that this evaluation is of historical interest only as TRU waste is no longer authorized for B693 by this DSA.

B.4 References

WM/WT-B696-0201, “Structural Response in Airplane Crash,” S.Y. Kim, October 2002.

Wall (1974), “Probabilistic Assessment of Aircraft Risk for Nuclear Power Plants,” Ian B. Wall, *Nuclear Safety*, Vol. 15, No. 3, p. 276, June 1974.

Personal communication from S.Y. Kim to H. Larson, regarding structural analysis of Building 693 under an accidental crash of a light airplane, October 19, 2004.